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ABSTRACT

This manual is designed to provide Peace Corps trainers with suggested guidelines on the presentation of a nutrition-oriented household food production training program to community-level field workers. The manual describes and discusses simple, low-cost, local resources that may be available to the community. When applied through a home garden, these resources can help ensure a continuous supply of food and therefore improved health. The information presented attempts to reflect the realities of a typical rural situation in the humid tropics in which a trainee will most probably work. The manual is organized in three sections. The first section provides a listing of the tasks that need to be done in order to conduct a workshop. Also included is a complete bibliography for all reference materials needed and samples of invitation letters, evaluations, and other items. The second section contains the schedule and an outline for each session in the training program. Written in the form of lesson plans, the session outlines suggest topics and activities and some problem-solving assignments. The final section is designed to provide the trainee with a general outline for producing crops in a mixed garden system. An appendix contains numerous references for additional study. (KC)

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TRAINING FOR DEVELOPMENT

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Nutrition Improvement Through Mixed Gardening

A Training Manual

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Peace Corps

NUTRITION IMPROVEMENT THROUGH MIXED GARDENING IN THE HUMID TROPICS

A TRAINER'S MANUAL

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

AND

U.S. PEACE CORPS

Prepared by

Paul Sommers

under

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This trainer's manual was edited and is being distributed by the League for International Food Education (L.I.F.E.).

Funded by the Office of Nutrition of the U.S. Agency for International Development, L.I.F.E. is a consortium of the leading U.S. professional societies concerned with food and nutrition. It functions as a clearinghouse for information for developing countries on all aspects of food, its production, harvesting, storage, processing, preservation, marketing, and nutritional value.

L.I.F.E. has had a long-standing interest in small-scale food production in general, and home gardens in particular. Thus, we are glad to have a hand in the production and distribution of this trainer's manual. It will, we believe, prove a useful tool in spreading a useful concept. Nutrition-oriented mixed gardens may not be the entire answer to the developing world's food problem; but they are certainly a <u>part</u> of the solution.

We hope that those who use the manual will send us any suggestions and criticisms so that future editions may reflect their experience.

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INTRODUCTION

This manual is designed to provide trainers with suggested guidelines on the presentation of a nutrition-oriented household food production training program.

The trainees are community level field workers who have little or no formal or practical experience in home gardening. They are interested in the potentially positive role that home gardening can play in solving family health problems.

The purpose of the manual is to describe and discuss simple, low-cost, local resources that may be available to the community. When applied through a home garden, these resources can help ensure a continuous supply of food and therefore improved health. Crop husbandry practices, such as pest and weed management, and plant nutrition are based on materials produced in the home garden on a sustainable basis that ecologically enhances the home environment.

Mixed gardening is the term that will be used throughout the manual. It is a combination of annual and perennial crops and small livestock. Grown in a continuous multi-story canopy structure, plants with different space and growth requirements are combined to permit maximum production in a limited space.

The advantages of mixed gardening over other methods of gardening--promotes environmental stability, is of high nutritional quality, and does not require high capital expenditures--are highlighted.

The importance of nutrition and its connection to food production are considered throughout the training course. Discussion topics include the nutritional and non-nutritional factors that can influence the nutritional status of an individual as well as village level activities that can improve nutrition.

The information presented attempts to reflect the realities of a typical rural situation in the humid tropics[1] in which a trainee will most probably work. These realities are:

Women have little or no money to spend on household food production activities.

Government extension services for household food production activities are limited or non-existent.

Women already have a full daily schedule; they cannot spend much time on a household garden.

Plant materials do exist locally that can be used to improve the nutrition situation.

The Suggestions to the Trainer provides a listing of the many tasks which need to be done in order to conduct a workshop. Also included is a complete bibliography for all reference materials needed and samples of invitation letters, evaluations, etc.

[1]Although this manual has been written specifically for the humid tropics, it is felt that the training program can be adapted to highland, semi-arrid, and arrid areas, if special attention is paid to water needs, food preservation, and appropriate crop selection.

Section I: Curriculum contains the schedule and an outline for each session in the training program. Written in the form of lesson plans, the session outlines suggest topics and activities and some problem-solving assignments. The trainer may need to modify times, topics, or activities, or all three, to respond to location-specific situations.

Section II; Technical Guidelines is designed to provide the trainee with a general outline for producing crops in a mixed garden system. It begins with basic crop management functions, such as pest management, plant nutrition, and water management, and ends with harvesting.

The Appendix is required reading and contains numerous references for additional study.

SUGGESTIONS TO THE TRAINER

I. What to do before the training course

A. Obtain information

So that the training staff has a general overview of the host country situation, the host country should be requested to assemble relevant socio-economic and technical data on

1. On-going projects in food production and nutrition conducted by
   a. government ministries
   b. university research
   c. non-government organizations
   d. local households
2. Food production and nutrition, including information on
   a. agricultural production
   b. crop prices
   c. health/nutrition
   d. ethnobotany
   e. ethnonutrition
   f. community structure

B. Modify the training course

The basic training course should be reviewed and modified where necessary to

1. Complement the program objectives of the host country
2. Suit the particular needs of the trainees, e.g., school teachers, community development workers
3. Modify suggested training schedule

C. Select staff

The following staff positions are recommended

1. Lead trainer

   Overall responsibility for the training course, staff training; with the co-trainer, selects
   a. pre-training activities
   b. guest lecturers
   c. course materials, supplies, equipment, e.g., books, planting materials, audio-visual equipment, emergency medical kit)
   d. field sites to be visited
   e. post-training activities
2. Co-trainer

   Works with the Lead Trainer, as described in C. 1. above
3. Logistics coordinator

   Responsible for
   a. assembling and keeping track of all course materials
   b. preparing for field plot work
   c. co-ordinating recreational activities

d. co-ordinating arrangements between the host country office and the trainees
e. assisting trainees' in making travel and other personal arrangements

D. Secure training site

The trainees should be provided with the opportunity to learn in an appropriate environment which has the least amount of distraction. Universities, government training centers, or religious retreats are often suitable as training sites. The host country should identify the site before the arrival of the trainees.

The training site should meet the following criteria:

1. Agro-climatic environment similar to work sites of trainees
2. Classroom, garden, dining, and dormitory facilities fairly isolated from distractions of large towns/cities; electricity, is possible.
3. Traditional food production activities still practiced by local people.
4. Traditional mixed gardening sites which trainees can visit and observe easily accessible from the training site
5. Site accessible, if possible, to other agricultural workers, such as nutrition and agriculture personnel, so that they might contribute as guest lecturers
6. Equipped with or access to copying machine, typewriter, telephone (if appropriate)

E. Develop training schedule

A sample training schedule is provided on page 17 of the Trainer's Manual, Section I: Curriculum. The course is designed to last ten days with 19 primary sessions. In addition, there are four optional sessions. The training schedule should reflect both the goals of the host country's program and the needs of the trainees and <u>should be modified where necessary to meet the local situation</u>.

F. Arrange for and assemble materials, supplies, and equipment

After receiving a list of local traditional crops and farming tools from the host country, the trainer should request that arrangements be made to secure the needed materials. Delivery dates, especially for live planting materials, must be coordinated with their use in the training course.

The logistics coordinator should take charge of the materials and equipment, making sure that they are available for use at the proper times.

The trainees will work in groups of two so the planting materials should be based on that. The number of tools needed should be based on a set of tools for every three groups.

The following is an example of the materials and equipment needed for a training course of 30 people:

1. Written materials
   a. Pacy, A. *Gardening for Better Nutrition.* 1978. Milton Buechhoff, Intermediate Technology Ltd.; c/o PO Box 337; Croton on Hudson, New York 10520 USA. Telephone: 914/271-6500
   b. U.S. Peace Corps. *Intensive Vegetable Gardening,* No. R-25. 1981. Peace Corps; ICE M-701; 806 Connecticut Avenue, NW; Washington, DC 20526 USA. Telephone: 202/254-7386.
   c. UNICEF. *The UNICEF Home Gardens Hand-Book: For People Promoting Mixed Gardening in the Humid Tropics.* 1982. Information Division, A-1008; 866 UN Plaza; New York, New York 10017 USA. Telephone: 212/754-3370
   d. Sommers, P. *Low Cost Farming in the Humid Tropics: An Illustrated Guide.* 1983. Island Publishing; Sta. Mesa, P.O. Box 406; Manila, Philippines.
   e. Brownlee, A. *Community, Culture, and Care: A Cross-cultural Guide for Health Care Workers.* 1978. C. V. Mosby Co.; 11830 West Line Industrial Drive; St. Louis, Missouri 63141 USA.
   f. Trainer's Manual - Section II: Technical Guidelines (30 copies)
   g. Trainer's Manual - Appendix (30 copies)

2. Plant materials
   Select materials appropriate for the local situation
   a. Bamboo stakes, 12" long (60)
   b. Cassava cuttings (450)
   c. Sweet potato cuttings (450)
   d. Banana tubers (15)
   e. Pineapple suckers (450)
   f. Papaya seedlings (15)
   g. Yam tubers (50)
   h. Taro tubers (45)
   i. Climbing bean seeds (local), 1/2 lb
   j. Squash seeds (local), 1/2 lb

3. Land preparation materials
   a. Traditional garden tools (5 of each type)
   b. Tin cans (old motor oil type) - (15)
   c. Wood ash, 50-lb sacks (2)
   d. Bamboo poles, 2" diameter, 6' long (60)
   e. Bamboo poles, 1/2" diameter, 6' long (60)

4. Pest management materials
   a. Chilies, 100 gr
   b. Laundry soap, 15 packets
   c. Buckets, 1-gallon (5)

G. Inform the trainees

At least one month before the beginning of the training course, the following written materials should be sent to the trainees:

1. Letter of invitation in which the objectives of the training course are explained. (See sample on page 8 .)

2. Sample Questionnaire for Determining Food Production and Nutritional Needs at the Household Level. (See page 59.)

3. A Summary of Food Garden Activities. (See page 9 .)

H. Prepare mixed garden site

The land selected to be used as the trainees' field plot should be cleared of weeds and debris before the training begins by workers other than the trainees (possibly a local youth group). The trainee's time will be limited and will better be spent on the development of crop management skills. The land area should be sufficient to provide each pair of trainees with a 3m x 5m plot, with a 1m walkway between each plot. Leave a small area for the session on land preparation.

I. Design evaluation.

The training course should be evaluated at the mid-point and at the end. The training staff should prepare these evaluations together before the beginning of training as it will help them to focus as a team on what they want the trainees to get out of the course.

The mid-point written evaluation will provide the training staff with an overview of how the trainees see the course as well as with the trainees' suggestions on how to adjust the remaining sessions to best meet their needs. The final evaluation will provide insights into how to prepare subsequent training courses on nutrition-oriented mixed gardening.

Samples of mid-point and final evaluations are given on pages 10 and 11.

Additions and deletions reflecting unexpected training events may be made by the trainers just before the evaluations are copied and distributed to the trainees.

II. What to do during the training course

A. Meet daily with the staff

A daily meeting should be held with the entire training staff to

1. Review the previous day's activities.
2. Make adjustments in the program as needed.
3. Prepare flipchart materials, slides, equipment, etc., for the next day's activities.
4. Build staff into an effective and compatible training team.

Each member should be encouraged to participate by making observations and suggestions related to the training course.

B. Conduct mid-point and end of course evaluati

See I.I. for description.

C. Plan for graduation ceremony at end of the course. (See sample graduation certificate on page 12.)

III. What to do after the training course

The trainers and host country staff will need to develop a working plan for follow-up activities. Some of these include:

A. Review of trainee's individual project plans

A post-workshop meeting is suggested to be held between the host country program/training staff and the trainees. The purposes of the meeting would be to:

1. Present and critique each trainee's project plan
2. Develop a schedule for monitoring the field projects
3. Design evaluation activities

In addition, a date should be set for the entire training group to meet again to discuss their on-going projects.

B. Periodic monitoring of trainee's mixed garden projects

At the post-workshop meeting, participants should develop a project monitoring schedule, including a checklist of activities that should be completed within the schedule. The following is a general outline for a monitoring schedule:

One Year of Project Activities
in Nutrition-Oriented Mixed Gardening

Phase I (four months)

1. assessing needs with the community
2. developing project plan of action
3. implementation of project plan

Phase II (four months)

1. crop management lectures and activities
2. nutrition and health lectures and activities

Phase III (four months)

1. preliminary assessment of the project by the community
2. expansion from pilot project to integration by the community

C. Formal evaluation of the projects

Each project should be evaluated to determine if its objectives were met. Some areas for evaluation include:

1. Did a genuine improvement occur in the target groups during the course of the mixed garden project? What is the evidence?
2. What processes were used to encourage community participation in and ownership of this project?
3. What indicators show that the project is being integrated by the community into its system?

Sample Letter of Invitation

Dear Trainee:

The Government of (country) and the U.S. Peace Corps would like to invite you to a 10-day training course entitled, "Nutrition Improvement through Mixed Gardening in the Humid Tropics".

The goal of the course is to provide you with an opportunity to explore ways of improving nutrition through traditional food production practices. Basic skills for project development of nutrition-oriented mixed gardening will also be included. Commercial vegetable gardening will NOT be stressed.

Please fill out and complete the two enclosed questionnaires, "Sample Questionnaire for Determining Food Production and Nutritional Needs at the Household Level" and "A Summary of Food Garden Activities", and bring them with you to the course as they will be needed then.

The course will be held at (location) from (dates). The first session will begin promptly at (time) on (day, date). You may arrive on (day, date) if you wish.

I. Overview

The workshop on "Nutrition Improvement through Mixed Gardening in the Humid Tropics" was requested by the Government of (country) and the U.S. Peace Corps so that issues concerning food production and nutrition could be addressed.

It was felt necessary to examine: Traditional food production practices; an inventory of locally available and acceptable crops of high nutritional quality; and if nutrition improvement among the groups at risk could be realized by working within the traditional food system.

The need was also expressed for developing a plan of action for nutrition-oriented mixed gardening by (describe, e.g., school teachers and extension personnel).

II. Workshop Objectives

A. To provide a forum for discussing traditional (country) food production practices and their role in improving nutrition.

B. To develop plans of action for incorporating nutrition-oriented mixed gardening into existing program activities.

III. Trainees

The number of trainees will range between 20 and 30. Approximately __% will be from the Peace Corps. The Peace Corps Volunteers (PCV) are (describe). The (country) trainees will include (describe)

A Summary of Food Garden Activities

(If Applicable)

Name of Project:

Location:

Target Group:

Number of Participants:

Time Frame of Project:

Total Cost:

Objectives:

Activities:

Mid-Training Evaluation

Please check _____(name of country) _____ (American)

1. Technical content ____too basic? ____just right? ____too difficult?

_____

_____

2. Sequence of Sessions ____follow and build on each other? ____jumbled?
(if jumbled, please suggest ways to adjust this)

_____

_____

3. Trainers ____well prepared technically? ____organized?
____concerned with needs and interests of the group?

_____

_____

4. My particular needs and interests in nutrition-oriented mixed gardening are:

_____

_____

5. The best thing about this training is:

_____

_____

6. The worst thing about this training is:

_____

_____

7. Additional comments and suggestions:

_____

_____

Evaluation

Please indicate _____ (name of country) ____(PCV) ____ other

1. Were most of the sessions presented in the workshop applicable to your proposed project? (Explain)

_____

_____

_____

2. Having gone through the workshop, would you still maintain the title or would you suggest another title?

_____

_____

_____

3. The workshop emphasized building on traditional food production practices to improve nutrition. Do you think this approach is appropriate under your conditions?

_____

_____

_____

4. a. Please indicate 3 sessions that you found most useful and why.

_____

_____

_____

b. Please indicate 3 sessions that you found least useful and why.

_____

_____

_____

(continued)

After Workshop Activities

1. Now that you have completed the workshop, please outline your next (first) step in developing a nutrition-oriented mixed gardening project at your site.

2. What techniques for community involvement are appropriate in your area?

3. How do you plan to work with other government agencies on this project?

4. What type of Peace Corps staff support (follow-up) would be most useful to you in your mixed gardening project?

PEACE CORPS

THIS IS TO CERTIFY THAT

_____

HAS SUCCESSFULLY COMPLETED THE TEN DAY TRAINING COURSE

NUTRITION-ORIENTED MIXED GARDENING

AND HAS FULFILLED ALL REQUIREMENTS THEREOF.

MAY 4, 1984

DIRECTOR PC/WESTERN SAMOA

TRAINER

TRAINER

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SECTION I: CURRICULUM

Training Schedule

First Day

Morning	Introduction Logistics Expectations Session 1:	Overview of Nutrition-Oriented Home Gardens
Afternoon	Session 2:	Structure and Function of Mixed Gardening

Second Day

Morning	Session 3: Session 4:	Basic Human Nutrition Applying the Mixed Garden Approach to a Village Situation Part 1: Information Gathering
Afternoon	Session 5: Session 6:	Soil Management Land Preparation

Third Day

Morning	Session 7:	Applying the Mixed Garden Approach to a Village Situation Part 2: Field Observations
Afternoon	" "	" " "

Fourth Day

Morning	Discuss field observations Session 8:	Linking Baseline Information to Nutrition Improvement
Afternoon	Session 9: Session 10:	Selection of Crops and Livestock Maximizing Production in a Limited Space

Fifth Day

Morning	Session 11:	Design of a Mixed Garden
Afternoon	Session 12:	Construction of Trellis

Sixth Day

Morning	Session 13: Session 14:	Village Level Training Activities Case Study: Existing Garden Project (optional)
Afternoon	Free	

Seventh Day

Morning	Session 15:	Implementing a Garden Plan
Afternoon	" "	" " "

Eighth Day

Morning	Session 16:	Plant Nutrition
	Session 17:	Water Management
Afternoon	Session 18:	Pest Management
	Session 19:	Weed Management

Ninth Day

Morning	Session 20:	Review (optional)
	Session 21:	Project Design for Nutrition-Oriented Home Gardening
Afternoon	"	"

Tenth Day

Morning	Review of Project Designs
Afternoon	Graduation

If additional time is available:

Session 22:	Applying the Mixed Garden Approach Group Interview with Household (optional)
Session 23:	Harvesting (optional)

SECTION I: CURRICULUM

Session 1: Overview of Nutrition-Oriented Home Gardens

Time 2 hrs (classroom)

Goals:

(1) To discuss the major nutrition issues facing the country.

(2) To introduce the concept of a crop production system which is primarily oriented toward improving family food consumption.

(3) To explain the importance of this approach in overall community development.

(4) To discuss the current situation of nutrition-oriented agriculture, including problems and prospects.

(5) To discuss some nutritional and non-nutritional factors that affect the nutritional status of an individual.

Overview: The session will focus on the concept of designing a crop production project at a household, school, and community level, the expected outcome of which is to improve nutrition. The linkage between crop production and other activities in a household's food system and with community development projects will be discussed. Examples of current efforts in research and field programs, some problems and prospects, will be included.

Activities:

5 min	Trainer states goals and relevance of the session.
20 min	Group discusses the major nutrition issues in the country.
10 min	Trainees define "nutrition-oriented family food production" in writing.
15 min	Group discusses the definition of "nutrition-oriented family food production".
30 min	Small groups discuss how food production activities are linked with activities in the household food system, the importance of a food production scheme as part of an overall community development program, and the constraints in nutritionally-oriented gardening projects as well as prospects for improving the situation. (See Trainer's Note.)
40 min	Each small group presents a flipchart summary to entire group.

Materials: Flipcharts

Trainer's Note

Each trainee writes his/her definition of gardening and is then asked to read it to the group.

Request trainees to turn in their completed Questionnaires for Determining Food Production and Nutritional Needs at the Household Level. The trainer needs these questionnaires to prepare for Session 4: Applying the Mixed Garden Approach to a Village Situation Part 1: Information Gathering.

Each small group is assigned one of the following questions:

(1) How does family food production fit into the household food system? Some of the items to be included are: processing, food storage, food preparation, and infant foods.

(2) How can a family food production project be integrated into other community development activities such as primary health care, primary education, water, and sanitation?

(3) What are some of the problems and prospects for nutrition-oriented gardening projects?

(4) What are the nutritional and non-nutritional factors that influence the nutritional status of your community?

References*

Pacy, A., *Gardening for Better Nutrition.*

*Full bibliographic and order information are given on pages 15-16 for all references.

SECTION I: CURRICULUM

Session 2: Structure and Function of Mixed Gardening

Time: 3 hrs 10 min (2 hrs 10 min classroom; 1 hr field)

Goals:
(1) To introduce the trainee to the mixed garden system of crop production and its importance in the humid tropics.
(2) To explain the structure and function of a mixed garden.
(3) To develop field observation skills. (See Trainer's Note.)

Overview: The session will introduce the mixed garden system. It is divided into two sections:
(1) The structure of a typical mixed garden found in the humid tropics, its mixture of annuals and perennials and its ecological and agronomic characteristics.
(2) The multi-purpose function of a mixed garden and its nutritional and non-nutritional importance in the daily lives of households throughout the humid tropics.

Activities:

10 min	Trainer states goals and relevance of the session.
45 min	Trainer presents slide lecture on the importance of mixed gardening in selected areas of the humid tropics.
45 min	Trainer presents slide lecture on the structure of a typical mixed garden. Topics to be presented include the similarities between a natural primary forest and a mixed garden and plant composition, ecological benefits, self-sustainability, and agronomic benefits of a mixed garden. (See Section II: Technical Guidelines. Characteristics of the Multi-Layer Garden and Function of Mixed Gardening.)
30 min	Trainer presents slide lecture on the multi-purpose functions of a mixed garden. Discussion centers on but is not limited to the nutritional aspects of mixed gardening. Also included are the economic benefits, such as the garden's potential to supply fuel wood, building materials, cooking utensils, animal feed, spices, medicinal plants, dyes, perfumes, ornamentals, social and religious plants, et cetera.
	Discussion and review.
60 min	Walking tour to observe mixed gardens.

Materials: Slide projector
Slides

Trainer's Note

An outline of the structure and function of mixed gardening is in Section II: Technical Guidelines. Characteristics of the Multi-Layer Garden and Function of Mixed Gardening. Slides on the structure of a mixed garden should include examples of

companion planting under various climatic conditions. Slides should clearly show a multi-story mixture of annual with perennial crops.

The slides should illustrate the functions of mixed gardens and should demonstrate the multi-purpose aspects of mixed gardening. Slides on the functions of mixed gardens are available through the Health Section/OTPS.

If good examples of mixed gardens are within walking distance, a short tour should be conducted. Allow the trainees to observe and record the mixed garden activities for later discussion.

References

UNICEF. *The UNICEF Home Gardens Hand-Book: For People Promoting Mixed Gardening in the Humid Tropics.*

SECTION I: CURRICULUM

Session 3: Basic Human Nutrition

Time: 1 hr (classroom)

Goals: (1) To familiarize trainees with some nutrition issues in the country.

(2) To categorize the nutritive value of food.

Overview: This session will introduce some basic nutrition information including basic nutritional requirements of infants. The major nutrient deficiencies of the country, the major categories of food and their nutritive value, and methods for improving the diet through mixed gardening will also be discussed.

Activities

5 min	Trainer states goals and relevance of the session.
10 min	Trainees define "good nutrition" in writing.
15 min	Each trainee presents his/her definition for small group discussion. Small groups discuss major nutrition related diseases in the country and their causes and why mothers and young children require special nutritional consideration. Each group presents its findings to the entire group for discussion.
30 min	Trainer lectures on the major household food crops and their nutritive value and methods for improving the diet. (See Trainer's Note.)

Materials:
Flipchart
Food composition table
List of the most popular crops
Chart on the three main food groups
Human nutrition requirements
Slide projector

Trainer's Note

Small group discussions: Each group will be assigned the following questions:
(1) What are the major nutrition-related diseases in the country, their causes and cures?
(2) Why should pregnant and lactating women and children receive special nutritional consideration?
Each group will present its findings to the entire group for discussion.

Group discussion: The trainer may use the following outline to discuss the use of local crops and small livestock that could be raised in a mixed garden to produce a balanced diet.

Foods for Energy and Warmth (Carbohydrates and Fat)	Foods for Body Building (Protein)	Foods to Protect Health (Vitamins and Minerals)
Root crops	Fish and shellfish	Tree fruits
Tree crops	Tinned meat and fish	Vegetables
Grain crops	Dried peas and beans	Seaweed
Oils	Green leaves	Young coconut
Butter	Fresh meat	
Sugar	Mature coconut	
Honey		

Problem Solving Assignment: At the end of the session, the trainee should be asked to write one to two pages on the following:

Human Nutrition — Describe some of the non-nutritional factors that affect the nutritional status of the community you work in. Suggest how the situation can be improved.

References

Peace Corps. *Personal Health Training Manual.*

United Nations. *Manual on Feeding Infants and Young Children.*

SECTION I: CURRICULUM

Session 4: Applying the Mixed Garden Approach to a Village Situation
Part 1: Information Gathering

Time: 3 hrs 50 min (classroom)

Goals: To provide the trainee with guidelines on how to use a questionnaire as a tool to gather and apply information for designing a nutrition-oriented mixed garden project.

Overview: This session will address how to gather and evaluate village-level information necessary for project identification. Emphasis will be placed on the importance of location-specific activities.

Activities:

5 min	Trainer states goals and relevance of the session.
15 min	Overview of different ways to gather information; emphasizing a questionnaire as only one example.
30 min	Small groups (6 per group), using the Sample Questionnaire, will discuss the importance of gathering information, what information should be gathered, ways to gather information, how often it should be gathered, and typical problems in obtaining information. (See Section II: Technical Guidelines. Sample Questionnaire for Determining Food Production and Nutritional Needs at the Household Level.)
45 min	Each small group presents its findings to the entire group (10 minutes each). A group discussion follows.
15 min	(Optional) Summary of information from the questionnaires completed by the trainees prior to the training course. (See Trainer's Note.)
30 min	Each small group prepares to present a "role play" of an interview with a family regarding the structure and function of its home garden. Interview techniques for information gathering as well as problems in information gathering should be presented.
30 min	One or two groups present their role play.
45 min	Discussion and analysis.

Materials: Sample questionnaires collected during Session 1 should be returned for this session.

Trainer's Note

Small Group Discussions: Each group is assigned the following questions regarding the sample questionnaire:

(1) Why is gathering this information an important activity?
(2) Are there other areas where information needs to be collected?
(3) What are some techniques needed for gathering information using this questionnaire?
(4) How often, and from whom, should this information be gathered?
(5) What are some typical problems in obtaining this information in your area?

Summary of Questionnaires: The trainer should provide a country or regional profile (whatever is more appropriate) based on the information from the questionnaires completed by the trainees. Linkages should be made to points raised in the previous discussion.

Role Play:

Actors: Promoter, wife, husband, and a grandparent.

Scene: The promoter has contacted the family and has learned that they are interested in finding out about the structure and function of their garden. The promoter is invited into the house by the wife and grandparent. They are discussing the garden when the husband, forgetting the prearranged interview date, walks in and... (e.g., takes over the conversation or contradicts what his wife and grandparent have already said, etc.)

Discussion and Analysis: A discussion with only the role play participants should address the following:

(1) As (the wife, the husband, the grandparent, the promoter), how did you feel about your role?
(2) What were you trying to do?
(3) How effective were you?

Then the entire group should discuss:

(1) What happened in the role play?
(2) What techniques were used to obtain information?
(3) Were the techniques effective?
(4) How did the promoter adjust to the collection of information once the husband arrived?
(5) What are some alternative techniques for interviewing?

References

U.S. Peace Corps, *Agricultural Development Workers Training Manual, Volume III Crops,* Pages 127-149.

Sommers, Paul, *Household Food Production in Dry Areas: A Programmer's Guide.* Pages 29-31.

Brownlee, Ann Templeton, *Community, Culture, and Care: A Cross-cultural Guide for Health Care Workers.* Pages 3-24.

SECTION I: CURRICULUM

Session 5: Soil Management

Time: 2 hrs (1 hr classroom; 1 hr field)

Goals: To provide trainees with skills in:

(1) Observing the soil characteristics in a home garden.

(2) Making simple recommendations on improving soil management in a home garden.

Overview: A basic understanding of soil--its potential and limits--is a key factor in increasing the productivity of a home garden. The trainee's ability to identify soil characteristics and provide simple, low-cost recommendations will improve his/her extension efforts.

Activities:

10 min	Trainer states goals and relevance of the session.
30 min	Trainer and trainees discuss soil: what it is; why it is important to understand its characteristics; what are some of the activities included in soil management. (See Section II: Technical Guidelines. Outline of Some Activities in a Nutrition-Oriented Mixed Garden IV. Soil Management.)
20 min	Trainer presents slide lecture on trouble-shooting existing soil conditions in home gardens.
1 hr	Field session. The whole group visits an existing home garden, observes the soil conditions, and makes recommendations to improve soil management.

Materials: Slide projector
Slides **

Trainer's Note

Field Session Activities: Each trainee
(1) Collects a handful of soil and adds a little water.
(2) Feels the texture (fine or coarse).
(3) Observes the cohesion (whether soil holds together or falls apart).
(4) Observes the color (light or dark).
(5) Walks around an area. Observes the various colors of the soils. Notes the density of native vegetation.

**Slides: (1) Arid-low fertility.
(2) Arid-sandy
(3) Humid-wet
(4) Coral
(5) Lava
(6) Fertile soil-humid

SECTION I: CURRICULUM

Session 6: Land Preparation

Time: 2 hrs (1 hr classroom; 1 hr field)

Goals:
(1) To familiarize trainees with the most popular methods of land preparation for home gardening in the host country.
(2) To provide trainees with an opportunity to develop their own skills in land preparation.

Overview: Land preparation can have an important influence on potential crop growth and home garden yields. A clear understanding of the methods used and potential areas for improvement will help to improve extension efforts.

Activities:

10 min	Trainer states goals and relevance of the session.
30 min	Trainer and trainees discuss the importance of land preparation in the home garden and examples of observed land preparation techniques in the host country. (See Section II: Technical Guidelines. Outline of Some Activities in a Nutrition-Oriented Mixed Garden III. Implementation.)
20 min	Trainer presents slide lecture on various methods of land preparation in existing home gardens. (See same Section II citation above.)
1 hr	Trainees observe land preparation techniques under home garden conditio.
	Trainees perform land preparation techniques in their individual plots.
	Discussion and summary.

Materials:
Appropriate local tools
Slide projector
Slides**

Trainer's Note

Ask for a demonstration from experienced class members or from the agricultural training center. The size of the plot should be 3m x 5m. The trainees should participate after each activity is demonstrated. Activities may include:
(1) Cutting weeds
(2) Removing weeds
(3) Removing weeds with a hoe
(4) Digging soil with a hoe

Discussion:
(1) What are the most popular methods of land preparation?
(2) What steps are involved?
(3) Who is reponsible for land preparation?
(4) What tools are used?
(5) Is there a particular season when land preparation is done?

References

Sommers, Paul, *Low Cost Farming in the Humid Tropics: An Illustrated Guide.*

**Slides: (1) Cutting weeds
(2) Removing weeds
(3) Digging soil with hoe
(4) Staking planting area

SECTION I: CURRICULUM

Session 7: Applying the Mixed Garden Approach to a Village Situation
Part 2: Field Observations

Time: 9 hrs 10 min (8 hrs field; 1 hr 10 min classroom)

Goals: To develop skills in observing existing mixed gardening systems, especially the use of local resources.

Overview: Field observation on existing mixed gardening systems is linked to the previous classroom and small group discussions on the importance of documenting existing garden systems. This practical, on-site field work will provide trainees with an opportunity to discuss the structure and function of mixed gardening with actual practitioners. A group summary will follow.

Activities:

10 min	Trainer states goals and relevance of the session.
8 hrs	The group visits two existing mixed gardens, one in an urban area, the other in a rural area. Discussion and observation techniques are used to document the structure and function of each mixed garden.
1 hr	The trainer and trainees discuss the field visits in relation to applying the information to a village situation.

Materials: Camera
Notebook

Trainer's Note

Selection of Gardens: See Section II: Technical Guidelines. Checklist for Mixed Gardening.

Discussion: The group should discuss the following questions:
(1) How many of the trainees have similar gardens in their communities?
(2) What are some of the advantages and disadvantages of the mixed gardens visited?
(3) How do the trainees envision using the information obtained on the field visit in the community?

References

UNICEF. *The UNICEF Home Gardens Hand-Book: For People Promoting Mixed Gardening.*

SECTION I: CURRICULUM

Session 8: Linking Baseline Information to Nutrition Improvement

Time: 1 hr 45 min (classroom)

Goals: (1) To link baseline information with a project design for nutrition improvement.

(2) To develop motivational skills in involving the community in the design process.

Overview: Once an assessment of needs is accomplished, promoters need to involve the community. A critical area is assisting them to realize the importance of a project to correct the situation. Techniques in how to reach this goal will be explored in small groups. Small group findings will be presented to the entire group. Each group will also present "role play" on how to encourage a community to participate.

Activities:

10 min	Trainer states goals and relevance of the session.
30 min	Small group discussions center on how to apply baseline information to development of a project for improving nutrition. Emphasis is on how to involve the community in the design process.
45 min	The small groups present their findings and recommendations to the entire group.
20 min	A "role play" is performed on how to encourage the community to participate in the design of the nutrition improvement project.

Materials: Flipcharts

Trainer's Note

Small group discussions: Each group should be assigned the following questions:
(1) Once baseline information is gathered, how can it be used to develop a garden project?
(2) How can a promoter involve the community in assessing its own nutritional needs?

Role Play:

Actors: Promoter, village colleague, four members of a community organization

Scene: Promoter and village colleague are invited to make a presentation to a community organization on the nutritional status of the community. They recommend mixed gardening as one means of improving the situation. Some members are for the project; others are against it.

Discussion: A discussion with only the role play participants should address the following:
(1) What is your reaction to the role play?
(2) How effective were the promoters in involving the community in problem solving?

Then the entire group should discuss:

(1) What is your assessment of the techniques used for involvement of the group in the project?
(2) Was the community able to link its nutritional problems to gardening as a solution?
(3) How will this linkage affect its participation?
(4) Can you suggest alternative methods for community involvement?

Problem Solving Assignment: At the end of the session, the trainee should be asked to write one to two pages on the following:

Extension	Describe how you would teach the importance of linking household food production to family nutritional needs.

References

Section II: Technical Guidelines. Outline of Some Activities in a Nutrition-Oriented Mixed Garden.

SECTION I: CURRICULUM

Session 9: Selection of Crops and Livestock

Time: 1 hr 45 min (classroom)

Goals: To provide trainees with an outline of what to consider when selecting crops and livestock for a household food production project.

Overview: This section will present some of the factors that should be considered when selecting and designing a garden project. Included are physical and biological requirements, nutritional value, crop and livestock selection, and social and economic effects.

Activities:

10 min — Trainer states goal and relevance of the session.

45 min — Trainees discuss in small groups some of the factors to consider in the selection of crops and livestock for nutrition improvement. These include physical requirements, nutritional value, economics, and social value. (See Section II: Technical Guidelines. Outline of Some Activities in a Nutrition-Oriented Mixed Garden. I. C. Selection of Crops.)

40 min — Each small group presents a flipchart summary to entire group.

10 min — Group discussion.

Materials: Flipcharts

Trainer's Note

Each small group is assigned one of the following questions:
(1) What are some of the physical requirements to consider when selecting crops?
(2) What are some of the nutritional factors?
(3) What are some of the financial aspects?
(4) What role does the social value of a crop play in crop selection?

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Session 10: Maximizing Production in a Limited Space

Time: 1 hr 40 min (classroom)

Goals: To familiarize students with the principles and practices of mixed gardening through companion planting.

Overview: This session is the practical application of some of the information presented in Session 2: Structure and Function of Mixed Gardening. Particular attention will be paid to the concept of companion planting for maximizing crop production.

Activities:

10 min	Trainer states goals and relevance of the session.
30 min	Trainer and trainees discuss the advantages and disadvantages of row cropping/monocropping versus mixed cropping under home garden conditions. (A flipchart is necessary for this activity.)
30 min	Trainer presents slide lecture on the concept of companion planting. (See Section II: Technical Guidelines. Outline of Some Activities in a Nutrition-Oriented Mixed Garden II. Principles of Companion Planting.)
30 min	Trainers draws 3m x 5m garden plan using companion planting concept.

Materials: Slide projector
Slides
Flipchart

Trainer's Note

The following information should be presented on a flipchart:
(a) Crop
(b) Light requirement (sun or shade)
(c) Structure (erect or flat)
(d) Root structure (tap or fibrous)
(e) Maturity (fast or slow)

Slides should illustrate the concept of companion planting that is appropriate under actual village conditions.

In comparing mono cropping and mixed cropping, economics (time and materials), ecology, and nutrition should be mentioned. (See next page.)

References

Seymour, J., *The Self Sufficient Gardener.*

Jeavons, J., *How to Grow More Vegetables.*

Peace Corps, *Intensive Vegetable Gardening.* R-25 (Fig. 1.1 and 1.2)

Activity	Monocropping	Mixed Cropping
Economics	Clear land	Clear land, plant
Labor	Prepare raised beds nursery, transplant (labor intensive)	Plant/harvest (not labor intensive)
Materials	Imported inputs (seeds, tools, etc.)	Local inputs
Ecology	Exposes soil to sun and rain (erosion)	Keeps soil covered Self-regeneration
Nutrition	Available in boom (abundance) or bust cycle Usually exotics are of low nutritional value	Available on a continuous basis Usually of higher nutritional value

Principles of Companion Planting

Crop	Light Requirement	Structure	Root Structure	Maturity
Taro	Shade/part sun	Erect	Tap	Slow
Sweet potato	Part sun/ Part shade	Flat	Tap	Fast
Bean	Sun	Erect (pole)	Fibrous	Fast
Papaya	Sun	Erect	Tap	Slow
Pumpkin	Part sun/ Part shade	Flat	Fibrous?	Fast
Cassava	Sun	Erect	Tap	Slow

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Session 11: Design of a Mixed Garden

Time: 5-1/2 hrs (classroom)

Goals: To prepare trainees to draw a garden designed for household nutrition.

Overview: This exercise is designed to transfer the concepts and skills previously covered by the trainees into practical project development.

Trainees will be presented with a situation appropriate to their scope of work and through group effort will design a nutrition-oriented garden. Finally, individual trainees will design his/her own garden.

Activities:

1-1/2 hrs — Trainer presents the situation to the group and explains the main points that should be covered in the garden design. Each individual draws a 150 sq meter garden plot that will be used for actual planting. (See Section II: Technical Guidelines. Outline of Some Activities in a Nutrition-Oriented Mixed Garden. I. Design.)

4 hrs — The individual plans a nutrition-oriented garden according to his/her work situation.

Materials: Basic landscape design materials (pencil, ruler, plain paper)

Trainer's Note

The trainee's assignment is to draw a garden plan of 150 sq meters. The plan should include a mixture of annuals and perennials as well as a brief statement on why each crop was selected. (See Section II: Technical Guidelines. Chracteristics of the Multi-Layer Garden and Function of Mixed Gardening.)

References

UNICEF. *The UNICEF Home Gardens Hand-Book: For People Promoting Mixed Gardening.*

Samaka Service Center, *The Samaka Guide to Homesite Farming.*

Peace Corps, *Intensive Vegetable Gardening*, R-25

Appendix

SECTION I: CURRICULUM

Session 12: Construction of Trellis

Time: 2 hrs (1/2 hr classroom; 1-1/2 hrs field)

Goals: To familiarize trainees with the importance of trellising crops and to develop skills in selecting materials and method of construction.

Overview: A trellis is an important component in multi-story mixed gardening. It allows two or more crops to be grown in the location; it is protected from small livestock; and it serves as a plant support system in water-logged areas.

Activities:

5 min	Trainer states goals and relevance of the session.
30 min	Group discusses the importance of trellising. Trainer presents slide lecture on various crop combinations using a trellis.
45 min	Trainees are provided with a demonstration on how to construct a trellis (1m x 2m).
45 min	Trainees work in small groups and construct a trellis.

Materials: Local materials suitable for trellising, e.g., bamboo
Machete
Hoe or bar for post digging
Flipcharts

Trainer's Note

Group discussion should include the following questions:
(1) What is a trellis?
(2) Why is it important in a mixed garden system?
(3) What are local materials that can be used for construction?
(4) What are some crop combinations that can be grown on a trellis?

A flipchart illustrating the materials and procedure for constructing a trellis should also be presented.

After the fieldwork, the trainees should record the procedure they used in their trellis construction.

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Session 13: Village Level Training Activities

Time: 2 hr 5 min (classroom)

Goals:
(1) To familiarize students with the need for extension.
(2) To discuss methods and materials for promoting nutrition-oriented mixed gardening.

Overview: This session will explore the need for extension, what information should be extended, where the information comes from, and methods and materials that are appropriate for extension. Examples of extension activities will also be discussed.

Activities:

5 min	Trainer states goals and relevance of the session.
30 min	Entire group discusses the need for extension, where information comes from, what information should be extended, and why people want to hear information on nutrition-oriented mixed gardening. (See Trainer's Note.)
20 min	Small groups discuss one of the following questions: (1) How do you determine which extension activities for nutrition-oriented mixed gardening are appropriate under your local situation? (2) When and where should extension activities be held on nutrition-oriented mixed gardening? (3) What are the traditional forms of communication in your area and which ones are the most effective? (4) How do you work with community members with lower social-economic status without alienating the affluent community members? (5) What are some of the reasons why extension activities may fail?
20 min	Each group presents its findings to the entire group.
20 min	Entire group discusses the findings and makes recommendations.
30 min	Trainer and trainees discuss various extension materials appropriate under local conditions and how to design them to be location specific. Examples include booklets and posters or a wall chart of local seeds.

Trainer's Note

Questions for the initial discussion include:
(1) Why is there a need for extension activities in nutrition-oriented mixed gardening?
(2) What are you trying to extend?
(3) Where does the information come from?
(4) Why do people want to hear information on nutrition-oriented mixed gardening?

References

Peace Corps, *Agriculture Development Workers Training Manual, Vol II, Extension Skills,*

UNICEF, *Media Selection Wheel.*

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Session 14: Case Study: Existing Garden Project (optional)

Time: 1 hr (classroom)

Goals:
(1) To discuss and analyze the activities of one trainee's garden project.
(2) To make recommendations on how to improve the garden project.

Overview: A case study of an existing garden project will provide the trainees with an opportunity to use their analytical abilities. One expectation of the case study exercise will be recommendations on how to improve the garden project.

Activities:

5 min	Trainer states goals and relevance of the session.
20 min	One of the trainees presents information on his/her existing gardening project, including objectives, activities, target group, number of participants, time frame, and total cost.
40 min	Entire group discusses the project, analyzes areas of weakness, and suggests improvements.

Trainer's Note

One case study should be selected from the form, "A Summary of Food Garden Activities", that is included in the pretraining packet of materials.

After the case study has been presented, the following questions will need to be asked by the group:
(1) How was the project formulated?
(2) How and who determined the project objectives?
(3) How was the management structure determined?
(4) How was the garden technology selected?
(5) How are conflicts solved within the project?
(6) Who is in charge of the finances?
(7) How will it be determined if the objectives were met?

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Session 15: Implementing a Garden Plan

Time: 7-1/2 to 8-1/2 hrs (field)

Goals: To apply the acquired classroom information and field observation to actual gardening skills development.

Overview: This is the session where the trainees do hands-on field work. Initially, they will observe the steps involved in implementing a garden plan. They will then work as a group in planting a garden followed by planting of individual garden plots. Exposure to unforeseen situations that may arise in planting a garden is an important aspect of this exercise.

Activities:

10 min	Trainer states goals and relevance of the session.
20 min	Review of classroom and field observations.
4-5 hrs	Trainees first observe the steps involved in laying out the garden. After each skill is presented by the trainer, the trainees work as a group to implement the garden plan. Initial skill development will include land preparation, staking out the dimensions of the plot (3m x 5m), marking the eventual locations of the crops, constructing temporary fences, and constructing trellises. Next is plant material placement and digging of holes for plants. Organic plant material can be placed in the holes before planting. The final activities include watering, replacing stick markers, and protecting the new plants.
15-30 min	Group discussion on the activities accomplished.
2 hrs	Trainees implement the model garden designs on individual plots using the skills acquired in the group session.
15-30 min	Discussion and summary of planting exercise. (See Trainer's Note.)

Materials:
Local planting materials
Local tools
Local materials for trellising and fencing
Local plant protection materials
Local organic soil amendments

Trainer's Note

After the fieldwork,
(1) Ask if anyone has made a drawing of his/her completed 3m x 5m plot.
(2) Why is it important to make a record of the plot?
(3) What should be included in the record?
    a) The garden lay-out
    b) List of crops
    c) Number of crops

d) Method of propagation
e) Method of planting
f) Method of plant protection

Problem Solving Assignment: At the end of the session, the trainee should be asked to write one to two pages on the following:

Garden Design	Draw the actual garden that was established. Describe pre-planting work, plant materials used, number of plants planted, techniques for planting, plant protection techniques, and post-planting activities.

References

Sommers, Paul. *Low Cost Farming in the Humid Tropics: An Illustrated Guide.*

Jeavons, J. *How to Grow More Vegetables.*

SECTION I: CURRICULUM

Session 16: Plant Nutrition

Time: 3 hrs (1-1/2 hrs classroom; 1-1/2 hrs field)

Goals: To understand the importance of plant nutrition, especially its relationship to plant growth and nutritional value.

Overview: This session will present basic plant nutrition information, its role in plant growth, and its influence on the nutritional quality of the crop. Local plant nutrition maintenance techniques will also be discussed.

Activities:

10 min	Trainer states goals and relevance of the session.
40 min	Trainer and trainees discuss the importance of plant nutrition. Specific topics include the relationship between plant nutrition and plant growth and how plant nutrition is related to the nutritional quality of a crop. (See Section II: Technical Guidelines. Outline of Some Activities in a Nutrition-Oriented Mixed Garden. V. Plant Nutrition.)
30 min	Trainer presents slide lecture on techniques for improving plant nutrition by using locally available materials. Trainees present observations on local techniques for improving plant nutrition. (See Trainer's Note.)
30 min	Trainees observe some techniques for improving plant nutrition including the timing and placement of locally available materials.
30 min	Trainees apply the information presented to their individual plots.
10 min	Summary and discussion.
30 min	Trainees participate in a demonstration on the preparation and application of "Manure Tea".
	Trainees formulate and apply "Manure Tea" to their plots at a rate of 500 cc per plant.

Materials:
Slide projector
Slides**
Materials for formulating "Manure Tea"
- Manure (1 part)
- Water (3 parts)
- Container

Trainer's Note

Classroom: Have the students discuss linking plant nutrition and deficiency consequences with human nutrition.

Field Observations: Demonstrate plant nutritional deficiencies and local materials that can be used for improvement. Give a demonstration on the formulation and application of "Manure Tea", compost, and wood ash.

Collect examples of common plant nutrition deficiencies as well as local fertilizers and display them in the classroom prior to the field session.

**Slides: Materials for plant nutrition
a) Compost pit
b) Wood ash
c) Manure
d) Green legume plants

References

Peace Corps, *Soils, Crops, and Fertilizer Use Program and Training Journal No. 8.*

Samaka Service Center. *The Samaka Guide to Homesite Farming.*

UNICEF. *The UNICEF Home Gardens Hand-Book: For People Promoting Mixed Gardening.*

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Session 17: Water Management

Time: 2 hrs (1 hr classroom; 1 hr field)

Goals: To familiarize and develop basic skills in simple techniques of water management.

Overview: Water management is a key factor in producing crops the year round. Discussion will center on different seasons. Simple moisture conservation methods and materials will also be presented.

Activities:

10 min — Trainer states goals and relevance of the session.

30 min — Trainers presents a slide lecture on the importance of water management and examples of practices in home gardens.

20 min — Trainer and trainees discuss local water management techniques according to seasons. (See Section II: Technical Guidelines. Outline of Some Activities in a Nutrition-Oriented Mixed Garden. VIII. Water Management.)

30 min — Trainees participate in a field demonstration on simple techniques that can be done under home garden conditions.

30 min — Trainees apply water management techniques in their plots.

Materials:
Slide projector
Slides
Watering containers

Trainer's Note

Slides should demonstrate the following:
(1) Systems of water conservation through mulching.
(2) Gardening near sources of underground water such as water pumps and hand dug wells.
(3) Use of rain water catchments for irrigation of garden crops.
(4) Growing drought tolerant crops.

References

Peace Corps, *Intensive Vegetable Gardening*. Pages 90-95.

SECTION I: CURRICULUM

Session 18: Pest Management

Time: 1 hr 40 min (40 min classroom; 1 hr field)

Goals:

(1) To familiarize the trainees with some of the most common plant damage associated with insects and diseases.

(2) To develop skills in simple diagnosis and recommendations for preventive pest management.

Overview: Pest management is an area of concern in crop production, especially in the humid tropics. The trainees should develop skills in diagnosis, recommendation, and preparation of simple pest deterrent measures. Emphasis will be on seasonal identification of the major types of insects (sucking and chewing) and diseases (fungus and virus) and the type of damage to plants above and below the soil. Recommendations for pest management will be based on locally available materials.

Activities:

10 min	Trainer states goals and relevance of the session.
30 min	Trainer and trainees discuss methods of control based on local technology and materials. (See Section II: Technical Guidelines. Outline of Some Activities in a Nutrition-Oriented Mixed Garden. VI. Pest Management.)
30 min	Trainees participate in a demonstration on the preparation and application of pest management materials.
30 min	Trainees formulate and apply pest management materials based on local techniques to their plots.

Materials: Local pest management materials
- chili
- garlic
- soap
- wood ashes

Trainer's Note

Preparation of Hot Pepper Spray

Grind hot pepper pods and mix with equal amount of water
(Example: one tablespoon of pepper and one tablespoon of water.)
Add a teaspoon of soap powder.
Dilute to 1:20 with water.
Apply formula through a filter.

Preparation of Garlic-Pepper-Soap Spray

2 garlic cloves (crushed)
2 tablespoons pepper (crushed)
1/2 packet of soap powder
1 cup hot water
Mix ingredients together.
Filter into one gallon of warm water.

Slides should demonstrate the following:

Pests and diseases
(1) Chewing damage
(2) Sucking damage
(3) Fungus on leaves
(4) Fungus on roots

Materials for control
(5) Companion planting
(6) Spices (chili, garlic)
(7) Soap
(8) Removal by hand of diseased plant part

Collect samples of common insects and diseases and display them in the classroom prior to the pest management field session.

References

Appendix, Pages 85-106.

SECTION I: CURRICULUM

Session 19: Weed Management

Time: 2-1/2 hrs (1-1/2 classroom; 1 hr field)

Goals: (1) To familiarize students with the importance of weed management in home gardens and methods of control.

(2) To develop skills in methods of weed management.

Overview: Effective weed management can lead to improved crop yields and more food for households. Several proven techniques using locally available materials can be used under home garden conditions. The trainees will receive instruction in how to prevent weeds from growing before planting and how to control them if they are already established.

Activities:

10 min — Trainer states goals and relevance of the session.

45 min — Trainer presents slide lecture on the importance of weed management and methods of control.

30 min — Trainer and trainees discuss local techniques of weed management. (See Section II: Technical Guidelines. Outline of Some Activities in a Nutrition-Oriented Mixed Garden. VII. Weed Management.)

30 min — Trainees observe a field demonstration on various techniques of weed management using local materials.

30 min — Trainees apply the techniques of weed management to their plots.

Materials:
Slide projector
Slides
Machete
Hoe
Organic materials for controlling weeds

Trainer's Note

(1) Make a collection of local plant materials than can be used as mulch.
(2) Collect samples of the most common weeds and display them prior to the weed management field session.

Slides should cover:
(1) Mulching with crop residue (2) Companion planting (shading) (3) Hoeing and machete (4) Burning weeds (5) Growing vines as a "living mulch"

Problem Solving Assignment: At the end of the session, the trainee should be asked to write one to two pages on the following:

Crop Management — Describe how you would apply the crop management information obtained during the training course to your particular field situation. What methods would be used and why?

References

Appendix, Pages 107-110.

SECTION I: CURRICULUM

Session 20: Review (optional)

Time: 2-1/4 hrs (1-1/4 hr classroom; 1 hr field)

Goals: To review the topics covered during the classroom and field sessions. To redefine home gardening.

Overview: This session will review selected aspects from the topics covered during the first ten days of training. It will provide an opportunity for group discussion both in the classroom and at the field plot site.

Activities:

30 min	Redefinition of home gardening.
45 min	Group discusses the importance of the classroom and field sessions and how they relate to their field sites.
1 hr	(Field Site). The trainer reviews the practical skills presented. The trainees discuss the information covered with the trainer.

Trainer's Note

To involve the entire group in the review process, the following questions should be asked:

1. What was the most important session for you and why?
2. Explain the importance of linking food production activities to nutritional needs and the process by which this is done.
3. What was the most important aspect you learned for community involvement?

SECTION I: CURRICULUM

Session 21: Project Design for Nutrition-Oriented Home Gardening

Time: 13-1/4 hrs (10-1/4 hours individual work; 3 hrs review with trainer)

Goals: To provide the trainee with an opportunity to apply the information presented in the training course to a practical program for nutrition-oriented household food production.

Overview: In this final session, the trainee will develop a village level project to improve food intake from home gardening activities, combining technical information on crop production and nutrition with project management information. The project should include year-round activities. The technical part of the project design should be based on the available local resources. The management part should include maximizing community participation. The entire project cycle from needs assessment to evaluation should be covered.

Activities:

15 min Redefine "nutrition-oriented mixed gardening".

10 hrs The trainee, reviewing the information presented during the training course, designs a nutrition-oriented home gardening project. Some of the subjects to be included are:

(1) What are the objectives of the project?

(2) What methods will be used to determine household food and nutritional needs?

(3) In what ways will community participation be encouraged throughout the project cycle, including needs assessment, project design, implementation, monitoring, and evaluation?

(4) What food and nutrition activities will be covered in the project?

(5) What criteria will be used in selecting plant materials and other inputs (garden design)?

(6) What approach will be used to motivate households to orient their gardening activities towards improving family food intake?

(7) What evaluation methods will be used to determine if the home garden project is truly improving nutrition?

(8) How can the project be assured to move from the pilot phase to actual integration by the community?

(9) What is the specific role of the community worker in the project?

(10) What is the total cost of the project?

(11) What is the time frame for project activities such as
--needs assessment (baseline information)
--project design
--implementation
--monitoring
--evaluation?

3 hrs Trainer meets with each trainee individually to review his/her project design.

Trainer's Note:

The following outline is suggested for the project design:

(1) (Cover page) summary of garden activities
    Name of project
    Location
    Target group
    Number of participants
    Time frame for project
    Total cost

(2) Background to the project (needs assessment)

(3) Objectives of the project

(4) Implementation (plan of activities and estimated time frame)

(5) Inputs (community worker/community)

(6) Evaluation (process/product)

SECTION I: CURRICULUM

Session 22: Applying the Mixed Garden Approach
Group Interview with Households (optional)

Time: 6 hrs (4 hrs field; 2 hrs classroom)

Goals: To provide trainees with an opportunity to select and collect basic information from households having mixed gardens.

Overview: The trainees will work in small groups and interview households regarding their mixed gardens. The interview techniques and observation methods will be based on the previous two sessions. Each group will present its findings to the entire group.

Activities:

10 min	Trainer states goals and relevance of the session.
4 hr	Small groups select and interview households and document the structure and function of their mixed gardens.
90 min	Small groups present their findings to the entire group.

Materials: Note Pad
Camera

Trainer's Note

See Section II: Technical Guidelines. Checklist for Mixed Gardening.

Small group interviews: The groups should be transported to a nearby village where they will work independently to develop interview skills and methods of observation. A central departure location and time should be decided upon in advance to make sure all the trainees return to the training center.

Discussion: The following questions should be answered in the findings reported to the entire group:

(1) What is the present structure and function of the interviewed household's mixed garden?
(2) What are some recommendations for improvement?

SECTION I: CURRICULUM

Session 23: Harvesting (optional)

Time: 1 hr 5 min (classroom)

Goals: To provide guidelines on harvesting for maximum nutrition and on establishing a "living storage" unit.

Overview: Proper timing in the harvesting of crops can improve the nutrient content. In addition, certain types of crops can be continuously harvested while others can remain in the garden until needed.

Activities:

5 min	Trainer states goals and relevance of the session.
30 min	Trainer presents slide lecture on techniques for improving the nutritional content of garden crops as well as examples of living storage units.
30 min	Trainer and trainees discuss local harvesting practices and ways to improve them. (See Section II: Technical Guidelines. Outline of Some Activities in a Nutrition-Oriented Mixed Garden. IX. Harvesting.)

Trainer's Note:

Select slides that illustrate:
(1) The proper time to harvest crops
(2) Examples of living storage units

References

Appendix. Pages 118-121.

PROBLEM SOLVING ASSIGNMENTS

(length: 1 to 2 pages)

Subject	Assignment
1. Human Nutrition	Describe some of the non-nutritional factors that affect the nutritional status of the community you work in. Suggest how the situation can be improved.
2. Extension	Describe how you would teach the importance of linking household food production to family nutritional needs.
3. Crop Management	Describe how you would apply the crop management information obtained during the training course to your particular field situation. What methods would be used and why?
4. Garden Design	Draw the actual garden that was established. Describe pre-planting work, plant materials used, number of plants planted, techniques for planting, plant protection techniques, and post-planting activities.

DIETARY INFORMATION

Information about local dietary patterns, in terms of availability, preference, and taboos should be collected in order to develop a program which the local people can accept and assimilate into their lives.

1. Twenty-four hour recall of food consumed. (Meal, amount, and source)

   Obtaining data on daily food intake, in terms of quality, quantity, and source should reveal dietary deficiencies, and indicate the major sources of daily food, i.e., own field crops, market, garden, friends, etc.

2. Which is the most common method of food preparation? (mixed and unmixed) How are these foods stored? How many meals are prepared daily?

   Understanding how food is prepared will help to determine the nutritional value of the meal. This data can be incorporated into a nutrition education program.

3. Which foods are in demand but are not purchased because of the high cost?

   A solution to the problem may be discovered by analyzing the factors involved in the high cost.

4. Are dietary intakes different among members of the household? Are there foods that are served during illness? For treating diseases? Which foods are they and on what occasions are they served?

   Food consumption patterns and taboos may be obstacles to improving nutritional status. Analyzing these obstacles may lead to their elimination, with the aid of the local community.

5. Do dietary intakes vary according to season? Do the sources (market vs. gardens) vary according to season?

   Obtaining data on food availability according to season will help to determine periods of shortages.

6. Are there certain foods that make one strong and healthy? Which foods would be included in the ideal diet? If these foods are not consumed regularly, what are the reasons?

   Understanding the linkage between food selection and diet will help in developing a more appropriate nutrition education program.

SECTION II: TECHNICAL GUIDELINES

Characteristics of the Multi-Layer Mixed Garden

I. Agronomically

By a system of companion planting, multi-layer mixed gardening:

A. Makes effective use of available light by grouping plants that have different light requirements (sun and shade tolerant).

B. Utilizes varying soil conditions:

1. Wet areas: taro, sugar cane, water cabbage, etc.
2. Dry areas: legumes and some fruit trees

C. Utilizes varying soil fertility:

1. Low fertility: shrubs and some trees (cashew)
2. High fertility: fruit-producing vegetables

D. Maintains crop production on a continuous basis by combining short-term annuals with long-term perennials.

E. Controls insects and disease by plant diversity:

One pest is attracted to a specific plant and will not attack most other plants.

F. Controls weeds by shading the ground with ground cover plants.

G. Produces the maximum amount and variety of plants in a small, limited space.

II. Ecologically

In this system:

A. Crops are grown by local renewable resources including plant food produced by decaying plant and animal residues. Fertility of the soil is maintained over a long period.

B. Soil is protected by growing ground cover plants, such as vines and sweet potatoes, to prevent soil erosion in the wet season and to conserve soil moisture in the dry season.

C. Small livestock are allowed to roam freely and provide fertilizer as well as eating insects and weeds.

D. Herbs also repel certain insects.

III. Economically

Mixed gardening is an example of a low input/high output farming system.

A. It is low in cost because the plant materials and other inputs are available in the local environment.

B. It is low in labor because most of the crops require little management, mostly planting and harvesting.

C. It saves income because families grow what they might usually purchase in the market.

D. It avoids high cost fertilizers and pesticides.

E. It may also generate income because the surplus crops can be taken to the market and sold.

IV. Nutritionally

For the family:

A. Seasonal food shortages are minimized because of plant diversity.

B. Nutritional balance of foods is also high, mixing legumes, root crops, leaf and fruit vegetables, livestock, and fruit trees.

C. Food storage is not a major problem; the garden acts as a living storage unit for root and leaf crops.

D. Food preparation: Food for the family meal can be harvested just before preparation, thus retaining more nutrients.

In summary, this system is a noteworthy example of effective resource management which is appropriate for even the poorest households.

SECTION II: TECHNICAL GUIDELINES

Functions of Mixed Gardening

Banana, coconut, ipil-ipil, and bamboo are usually considered essential for low-cost farming because they provide multiple functions.

Functions of Essential Low-Cost Farm Plants

Banana	Coconut	Ipil-Ipil	Bamboo
Animal feed	Fuel	Fuel	Fuel
Shade	Building	Fertilizer	Trellising
Protection for seedling	Mats	Building materials	Plant protection
Leaves for cooking	Scrub brushes	Trellising	Animal shed
Compost pit	Seed storage	Fencing	Plant nursery
Food	Weed control	Feed	Housing
Mushroom growing	Fencing		Furniture
	Stakes for climbing plants		Baskets
	Cooking oil		Fishing poles
	Lamp oil		Plant stakes
	Water (juice)		Fencing
	Furniture		Seed storage
	Baskets		Water containers
	Shade		Cooking utensils
	Animal feed		Drinking cups
	Natural trellis		Mulching
	Food		Bed frames
	Oil as a preserver		
	Cooking utensils		
	Drinking cups		

SECTION II: TECHNICAL GUIDELINES

Checklist for Mixed Gardening

1. The garden provides a variety of food, medicinal, and building materials. (The greater the diversity, the greater the chance for adaptation by the local people.)

2. The plant canopy is multi-storied, making efficient use of energy. (A large number of crops can be grown in a limited space without significantly competing with one another.)

3. The garden provides better use of soil water and soil nutrients through its various root zones levels. (A large number of crops can be grown in a limited space without significantly competing with one another.)

4. Weed growth is controlled through shading by the upper canopy level and by trailing edible vines. (Controlling undesirable growth gives the desired plants a good opportunity for growth.)

5. Mixed-crop planting arrangements are such that a high plant diversity is achieved. (Makes maximum use of a limited growing area.)

6. Plant material is available locally and can be easily propagated. (Lessens dependence on non-local resources.)

7. The plant has the capacity for identical parental regeneration. (Reduces the chance of losing desired qualities.)

8. Crops grown require little or no commercial pesticides and fertilizers. (No necessity to spend severely limited funds on food production.)

9. Crop combinations have biological crop protection and synergistic relationships for nutrients. (Companion planting increases crop production efficiency.)

10. Organic matter is allowed to remain in the garden and additional nutrient sources, from farm animals, the family, and threshing, are applied to the plants. (Using on-site materials removes the need for fertilizer expenditures.)

11. A steady supply of crops is harvested throughout the year. (Provides food and other essentials during staple crop shortages.)

12. Labor requirements are minimal and do not interfere with the major income activity. (Essential to integrate into daily activities.)

13. The garden provides a variety of quality nutrients throughout the year to ameliorate deficiencies in the diet. (Provides the opportunity for a good dietary intake throughout the year.)

14. The garden is unlikely to create conditions that will damage the ecosystem.

SECTION II: TECHNICAL GUIDELINES

Sample Questionnaire for Determining Food Production and Nutritional Needs at the Household Level

The following questions have been designed to provide information about the financial status of households and how it relates to nutritional intake. It will not always be possible to get complete information, even from a sampling of households. It is worth remembering that if the home garden program is seen as part of an economic benefit package, the chances for motivating families to respond and participate will increase.

Financial Information

1. Name, age, sex, and occupation of family members currently residing in the household.

   (The family composition will determine the nutritional needs of the household. Occupation will indicate the potential income available to the household. Refer to the host government's food composition table, if available, to determine the food/nutrition needs for the household.)

2. What is the approximate annual income of the family?

   (Household income will provide an indication of disposable income and purchasing power.)

3. Is income seasonal or steady throughout the year?

   (Fluctuating incomes have a direct influence on nutritional intake. It is important to determine the high and low income months so that the home garden may be designed to meet the household's economic and nutritional needs.)

4. How much money is spent on food per week?

   (Expenditures for food compared with income provide an approximate percentage spent on food.)

5. Which items are usually purchased?

   (Examine items purchased to determine which could possibly be produced in the home garden.)

6. Determine the approximate frequency of shopping and distance to the marketplace (in time and distance).

   (Perhaps a home garden could be designed to reduce the number of trips and the amount of time spent in marketing.)

7. Does the amount spent on food vary according to season?

   (If expenditures vary according to season, then it would be appropriate to design a home garden for the months when the family need for garden produce is the greatest.)

Dietary Information

Information about local dietary patterns, in terms of availability, preference, and taboos should be collected in order to develop a program which the local people can accept and assimilate into their lives.

1. Twenty-four hour recall of food consumed. (Meal, amount, and source).

   (Obtaining data on daily food intake, in terms of quality, quantity, and source should reveal dietary deficiencies, and indicate the major sources of daily food, i.e., own field crops, market, garden, friends, etc.)

2. Which is the most common method of food preparation? (Mixed and unmixed).

   (Understanding how food is prepared will help to determine the nutritional value of the meal. This data can be incorporated into a nutrition education program.)

3. Which foods are in demand but are not purchased because of high cost?

   (A solution to the problem may be discovered by analyzing the factors involved in the high cost.)

4. Are dietary intakes different among members of the household?

   (Food consumption patterns and taboos may be obstacles to improving nutritional status. Analyzing these obstacles with the aid of local community leaders may lead to their elimination.)

Home Garden Information

Traditional home gardening practices were developed to meet basic human needs. As we have seen, a home garden project will be more likely to succeed if local technology is incorporated. Observing the structure and function of the home garden will provide insight into how members of the household perceive their garden in relation to their daily routines.

1. What is the major staple produced by the household, and when? (Area and quantity.)

   (The main staple crop is usually the focal point of family and village activities. A home garden project can be designed to complement the staple crop in terms of time, allocation, and nutrition.)

2. Why was a home garden constructed? (Income, home consumption, or other).

   (The answer may lead to a further understanding of the various activities that take place in the garden.)

3. How was the design of the home garden decided?

   (This will provide an insight into the garden's structure and function. A garden which is primarily for income will most probably show a distinctive "market garden" appearance. On the other hand, a subsistence garden generally will appear to have a great variety of plants mixed together in a limited space.)

4. How was the home garden location decided?

   (This will provide information as to whether or not garden plants were grown in a certain place for a particular reason.)

5. How was the choice of plants made? (Family preference, climate, income, nutritional value, or other).

   The answer will indicate the family's major considerations. The garden may have other functions besides the production of food.)

6. Major sources of plant materials. (Markets, friends, relatives, farms, or other).

   (This knowledge will help in developing the seed distribution phase of the project.)

7. How many family members work in the garden?

	Seldom	Often
All	_____	_____
Head of household	_____	_____
Wife/Husband	_____	_____
Other	_____	_____

   (The home garden program must be tailored for the target group.)

8. How many hours are spent working in the garden per day?

Less than half an hour	____
Between a half and one hour	____
Between one and two hours	____
More than two hours	____
Other	____

   (Time spent in the garden may be an indication of its importance relative to other household activities. Factors that determine time spent in the garden include type of crop, size of the garden, intensity of the planting, season of the year, major labor intensive staple crop.)

9. Approximate size of the garden.

   (It is important to appreciate that even if some space may appear available or unused, it may well be in use in an alternative non food-related capacity.)

10. a. What tools are used in the garden?
    b. Where are most of the tools obtained?

Made by household	____
Purchased in the marketplace	____
Donor group	____
Other	____

    (A knowledge of tools most commonly used in the home garden will assist program planners in deciding which tools are necessary, and also if they can be produced locally.)

11. What cultural management practices are used?

Activity	Season	Crops
Watering	_____	_____
Weeding	_____	_____
Cultivation	_____	_____
Staking	_____	_____
Fencing	_____	_____
Pest control	_____	_____
Chemical	_____	_____
Biological	_____	_____
Fertilizer	_____	_____
Commercial	_____	_____
Natural organic	_____	_____

(This information will reveal the degree of technical skill used on the crops. Program planners could design seminars on the use of locally available material for crop improvement.)

12. Which crops require the most time and care?

(If the answer shows that imported seed requires the most attention, promotion of locally adapted plant materials may be in order.)

13. a. Is there a surplus of crops?
b. Is there a shortage of crops?
c. If yes, during which season?

(This knowledge may assist in programming for home garden crops that are adapted to the climate at the time of shortage.)

14. Are crops traded from one household to another?

(Findings may indicate that trading is commonplace, and imply that money is not always necessary in order to obtain food.)

15. From what sources is food obtained on a daily basis?

	Most	Some	None
Market	____	____	____
Garden	____	____	____
Friends	____	____	____
Relatives	____	____	____
Other	____	____	____

(This answer will have major policy implications, indicating how the family obtains food for its survival. Without a clear understanding of the major food source, a home garden program is unlikely to succeed.)

16. Are farm animals raised in the home garden? If yes:

		Uses		Source of Feed	
Kind	Number	Income	Home Consumption	Market	Farm/ garden
Fish					
Chicken					
Duck					
Pig					
Goat					
Other					

17. What are the problems of this home garden?

Lack of space ____
Lack of planting materials ____
Lack of water ____
Insects and disease ____
Stray animals ____
Lack of time ____
Theft ____
Other ____

(Through a real understanding of the problems, possible solutions can be developed.)

18. List of crops and their uses:

Name of Crop	Amount	Use*

*Key:
1. Food
2. Fiber
3. Firewood
4. Building materials
5. Animal feed
6. Medicinal
7. Spice
8. Ornamental
9. Other

(This classification of plant and animal species and their uses will provide the basis for a self-sustaining home garden.)

SECTION II: TECHNICAL GUIDELINES

Outline of Some Activities in a Nutrition-Oriented Mixed Garden

I. Design

A. Village level

1. Project management aspects

a. Nutrition improvement project

1) Who will participate in the design and implementation of the project at the national and village level?

2) How will the nutritional priorities be determined at the village level?

3) What criteria will be selected to determine if the technical and operational design of the project will truly "improve nutrition"?

4) What approach will be used to involve households in realizing and solving their own nutritional deficiencies?

5) Who will be financially reponsible for the logistics of the crop inputs?

6) How will seasonal food and nutrition issues be managed?

7) How will the household food production project be linked to other activities in the food system and support other development activities?

8) How will the physical constraints of inadequate land and water be managed?

9) How will the actual project participants be selected?

10) What monitoring and evaluation techniques will be used to determine if there has been a genuine improvement in an household's nutritional intake?

11) Will the garden project only emphasize food crop production or will it have a multi-purpose role?

b. Income-generating project

1) Who will participate in the design and implementation of the project at the national and village level?

2) Who will be responsible for doing the research to make sure the project is truly "income-generating"?

3) Who will actually grow the crops?

4) Who will decide on the type of technology to use and which crops to grow?

5) Will the activity fit into the existing village social system?

6) What is the potential environmental impact?

7) Who will be in charge of marketing?

8) How will financing be initially arranged and continued?

9) Will a cooperative need to be established? If yes, who will manage it?

10) How will a favorable supply/demand ratio be maintained?

11) Is the amount of money spent per participant in the pilot project realistic and replicable in other areas without continuous foreign assistance?

2. Physical and biological resources

a. Physical resources

1) How much land is available for cultivation and is it available the year round?

2) Is the soil fertile or has it been depleted of soil nutrients?

3) Is the soil easy to cultivate by hand?

4) Are there periods of strong wind during the year?

5) Is there sufficient rainfall? If not, can water be stored or fetched from a public water source?

b. Biological resources

1) Are traditional plant materials locally available in sufficient quantities?

2) Are there new crops that can be adapted that would require little maintenance?

3) Is there a sufficient supply of local biological resources that can be used for fertilizer and other crop maintenance activities?

B. Household level

1. What is the present primary use of the land around the house?

2. Will domesticated animals be permitted to roam freely through the garden?

3. Will the garden serve a multi-purpose role supplying other items besides food?

4. Does the family have legal rights to the land?

5. How much land is actually available for a garden?

6. Is there access to water year round?

7. How much time can the household members afford to spend on gardening activities?

8. What, if any, are the seasonal nutritional deficiencies of the household members?

C. Selection of crops

1. Physical requirements

a. How adaptable is the crop to the local environment?

b. How long is the growing season?

c. What are the crop's management requirements?

d. Will the crop enhance the environment?

2. Nutritional value

   a. Does the crop have high food value with low maintenance requirements?

   b. What is the crop's potential for processing and storage?

3. Economic

   a. Does the crop have a low labor and financial requirement?

   b. Is the crop locally available?

4. Social

   a. What are the family food preferences?

   b. Does the crop have more than one purpose?

   c. Is the crop culturally acceptable?

5. Livestock

   a. Biological requirements

      1) Is the animal adaptable to the local environment?

      2) Will the animal not damage the local crop environment?

      3) Can the animal adjust to adverse climate and food supply situations?

   b. Economic

      Does the animal have a low maintenance and financial requirement?

   c. Social

      1) Does the animal have social value?

      2) Does traditional knowledge exist on husbandry practices?

E. The garden plan

Sketch a plan to include

1. The location of permanent fixtures in the garden, such as fencing, trees, livestock pens, house, etc.

2. The proposed location of annuals, perennials, livestock areas, trellises, fences, composting area, etc.

Note: Draw the plan to reflect how the garden should appear in 10-15 years.

II. Principles of companion planting

Maximizing production in a limited space requires an understanding of individual crop characteristics in terms of space and time.

A. Plant physiology (some factors to consider)

1. Root structure (tap or fibrous)

2. Plant height (erect or prostrate)

3. Light requirements (full sun or part shade)

4. Water requirement (drought tolerant or requires frequent irrigation)

5. Maturity (fast growing or slow growing)
6. Edible portion (roots, stem, leaves, fruits)
7. Plant nutrition sensitive to or tolerant of a wide range of soil conditions)

Once there is an understanding of a crop's characteristics, a system of companion planting can be developed. Companion planting can be effective with crops which have similar as well as different requirements.

B. Different requirements
   1. Shade tolerant with full sun (leaf crop and flowering crop)
   2. Short maturing with long maturing (>60 days and <100 days)
   3. Nitrogen producing with non-nitrogen producing (legume and root crop)
   4. Erect with prostrate (corn and squash)

C. Similar requirements
   1. Light (shade with shade)
   2. Water (drought tolerant)
   3. Plant nutrition (light feeders)
   4. Soil (heavy soil)
   5. Pest tolerance (resistant to insects and diseases)

D. Plants that grow well in "companion" plant combinations
   1. Sweet potato (okra, eggplant, tomato, chili, pole bean, yardlong bean, wing bean, lima bean, rice bean, jute, amaranth, corn, pigeon pea)
   2. Cassava (sweet potato, swamp cabbage, pechay, nightshade, lettuce, garlic, vine squash, peanut)
   3. Taro (sweet potato, swamp cabbage)
   4. Tomato, okra, eggplant (sweet potato, swamp cabbage, vine squash, radish)
   5. Corn (okra, tomato, sweet potato, bush bean, pole bean, cabbage, peanut, vine squash, yardlong bean)
   6. Vine squash (on trellis: bottle gourd, sponge gourd, cucumber, bitter melon, passion fruit)
   7. Bitter melon (on trellis: legumes, lima bean, yardlong bean, hyacinth bean, wing bean)
   8. Swamp cabbage (taro, sweet potato, cassava, tomato, okra, corn, eggplant; any crop on trellis: amaranth)
   9. Vine/legumes (on trellis or banana stalk)
   10. Yam (on fruit trees or trellis)
   11. Cucumber (corn, pole bean, radish, okra, eggplant)
   12. Tomato (sweet potato, radish, lettuce)
   13. Drumstick tree (sweet potato, swamp cabbage, pechay, nightshade, jute, lettuce, bush squash, yam, amaranth)

III. Implementation

A. Background

1. Household nutritional needs were determined
2. Year round garden plan was drawn

B. At the garden site

1. Start site preparation at the beginning of the rainy season
2. Have all the tools necessary at the garden site (knife, hoe, bamboo planting stick, watering container)
3. Have all other materials at the site (temporary fencing, crop protection, planting stock)

C. Land preparation

1. Cut weeds to the ground. Leave until dry. Remove rocks and other debris. Gather dried weeds into a pile and burn. Save the ash for use later.
2. Stake out the area for planting, indicating the location of holes to be dug. (This will show if the garden plan and actual implementation are compatible.)
3. Construct a temporary fence.
4. Construct trellises.
5. Dig all the holes for the seeds and seedlings before starting to plant. (If compost material is available, place a handful in each hole and mix with the soil.)

D. Planting

1. Start with the crops nearest to the fence and trellises.
2. When planting roots and tubers, such as taro, banana, and cassava, place the ashes from the weeds in the hole and mix with the soil. After planting the crops, apply a mulch of 6 cm around the plant. Next, provide protection from stray animals, strong rains, and sun. Finally, water the plant.
3. In transplanting seedlings of fruit trees and some vegetables, the same procedure would follow as that for the roots and tubers, except that ash is not necessary.
4. Direct-seeded vegetables require less attention and labor at the planting stage than the previously mentioned crops. After planting the seed, place a wooden marker next to it and water. Cover the area with leaves for a few days to conserve moisture. Mulch may be applied approximately one month after seed germination.

IV. Soil Management

A. Factors to consider

In the home garden, some of the factors to consider in appraising the potential soil for crop production include:

1. Texture (heavy clay to sandy)

2. Location (dry to wet)

3. Fertility (dark to light colored)

4. Present vegetation (where it is or is not growing)

5. Slope of land (hilly or flat)

B. Recommendations for action

After appraising the soil situation, recommendations for action may include

1. Soil texture improvement

a) Heavy soil may drain better with the addition of organic matter.

b) Sandy soil may retain more moisture and nutrients with the addition of organic matter.

2. Water-logged areas

Grow hydrophylic (water loving) plants, such as swamp cabbage, sugar cane, banana, and taro.

3. Dry areas

Drought tolerant crops, such as legumes and some trees

4. Darker colored soils (generally good fertility)

Crops that are sensitive to proper nutrition (most shallow rooted annual crops)

5. Lighter colored soils (generally poor fertility)

Most leguminous trees, some grains, and cassava (Regular additions of organic matter should improve the situation.)

6. Present vegetation

Grow sensitve crops in area with dense vegetation. Plant less sensitive crops in areas with less vegetation.

7. Slope of the land

a) Hilly areas should be planted with a combination of less sensitive annual and perennial crops.

b) Flat areas may be reserved for crops that require good soil fertility.

The conservation of organic matter should be encouraged as its utilization is generally linked with increased crop yields. This usually results in more food availability for the households.

V. Plant Nutrition

A basic understanding of plant nutrition:
The availability, absorption, and utilization of plant food is an important part of understanding the relationship between garden produce and nutrition.

A. The macronutrients and availability in the garden

1. Nitrogen

This element is most often needed by crops and is also the most difficult to provide to plants in the amount and frequency needed. Simply

stated, nitrogen in combination with other elements promotes active vegetative growth. Proper nitrogen levels at the beginning of the growth period will help ensure a smooth passage into the reproductive stage. Without nitrogen, plant growth will appear weak and yellowed--usually resulting in poor yields.

Under home garden conditions, several materials can be used to feed nitrogen to plants. These include the green leaves of leguminous plants, animal manure, and urine. Digging these materials into the soil will result in a more productive use of the nitrogen than placing it on the soil surface.

2. Phosphorous and Potassium

These elements combine with others in developing strong root, stem, and leaf cells to protect against pests. In addition, these elements are needed in the reproductive phase to produce flowers and fruits. Some common garden materials that can be used to supply phosphorous and potassium are the residues of banana and sugar cane plants as well as wood ash. The bones of livestock are also useful.

B. Plant nutrition and nutritional values

Plant nutrition and its effects on the mineral and vitamin content of fruits and vegetables must be considered in combination with garden practices such as irrigation and weed management and post-harvest operations, including handling, storage, and processing.

Plants require 16 elements in order to grow properly. If one of the 16 elements is not available in a sufficient quantity, then plant growth will be affected. This, in turn, will influence the nutritional value of the crop. For example, if iron is lacking in a plant grown for its leaves--then the amount of available iron along with other minerals for use as a food is less than food composition tables would normally indicate.

One good method for supplying nutrients is through compost. The composted material can be applied to the soil at a rate of 4 kg per sq meter and incorporated into the soil at a 15-20 cm depth.

V. Pest Management

Pest management is the control of harmful insects and diseases. Major pest infestations are generally seasonal, occurring mostly during the wet, humid period. However, pests tend to be less of a problem in home gardens (especially mixed gardens) than in modern conventional farming systems.

Some of the techniques for pest management:

A. Removal of diseased plants or plant parts

Often this is an effective control method for preventing the spread of a plant pest. A plant may be obviously under attack by insects or diseases. If the diseased parts are removed, spreading throughout the plant may be prevented. If that proves unsuccessful, removal and burning of the entire plant is advisable.

B. Companion planting

The natural mixture of plant species is the most effective passive activity for managing pests. Companion planting can combine 20-50 different plant

species and varieties. Pests are host-specific and attack only a certain range of plants. Growing and mixing a large number of different plant species will help prevent pest build-ups. Certain plants naturally repel insects and are resistant to diseases. Certain soil and airborne diseases can be prevented from spreading by combining plants with different heights and roots. In addition, maintaining proper plant nutrition will help control pests. Planting plants in their proper soil requirements is also a pest control method.

C. Home garden materials as pest control

Certain plants and other materials have been traditionally used to manage pest problems. Chewing insects have been repelled by using chili peppers and garlic. Sucking insects have been repelled by the combined use of soap, kerosene, and water. Some crawling insects are managed by spreading wood ash around a plant's base.

(For additional examples, see the Appendix: Some "Organic" (Non-Chemical) Pest Controls.)

VII. Weed Management

Weeds (unwanted plants) are a major pest in home gardens and can significantly affect a crop's growth and yield. Weed growth is most active during the humid, wet period in the humid tropics.

A. Weeds should be removed from the garden because they

1. Act as a place for insects and diseases
2. Compete with the garden crops for light, space, water, and nutrients

B. The removed weeds can be used for

1. Plant food (in the form of ashes or compost)
2. Livestock feed
3. Bedding for livestock
4. Mulch for water conservation and soil erosion
5. Packing materials for fruits and vegetables

C. Some techniques for managing weeds include:

1. Mulching

Mulching, the placement of decaying plant and animal residues on the soil surface, is an effective weed management technique. Mulch when placed at least 6 cm high around a plant will control weed growth by preventing sunlight from making contact with the soil. Decaying weeds can be used as a mulch to prevent other weeds from growing. In the rainy season, caution should be used so that the mulch does not provide an environment for the development of diseases.

2. Companion planting

Companion planting, a key element in mixed gardening, can also be an effective technique in weed management. Traditionally, the plant and animal residues produced under mixed gardening conditions are allowed

to remain in the garden. The combination of a layer of decayed organic matter and the shading of soil common in companion planting results in limited sunlight coming into contact with unprotected soil.

3. Hoe cultivation

   The physical removal of weeds by hoeing or slashing by knife is another technique for weed management under home garden conditions. This method is more frequently used during the early development of a garden when trees are still small and mulching material may be limited.

4. Burning

   Weeds can be removed by burning during the initial preparation of a garden and also after they have physically been removed and placed in piles. Fire is usually effective in destroying weed seeds and diseased plant parts above the surface.

5. Shading

   A mixed garden, with its combination of trees and animal crops, becomes an effective means of weed management as the garden matures. During the early years, the young structure of a mixed garden allows more sunlight to come in contact with the soil. However, as the garden matures, those trees create more of a shading effect on the soil, thus preventing weed growth.

VIII. Water Management

Water is the main constituent of a plant, composing up to 90%. The management of water under home garden conditions in the humid tropics requires applying a few simple techniques to assure year round crop production. (This section will discuss techniques for managing rainfall. For a discussion on hand-watering, see Pages 184-186 in *The Peace Corps Agricultural Workers Training Manual,* Volume III.)

Rainfall is rarely consistent in the humid tropics. One method for assuring that proper water management techniques are in place is to have a general knowledge of rainfall periods and their intensity.

During the period of heavy rain, soil erosion is a potential major problem. In a mixed garden, erosion is rarely a problem because the soil surface is usually covered by a combination of plants and mulching material. Also, during the rainy period, a simple roof rainwater catchment can be constructed to divert and conserve the excess water for the drier months.

During the drier months, home gardens tend to produce less. This is directly related to a lack of sufficient moisture to support particular plant growth. However, the combining of drought-tolerant crops with a mulch at the end of the rainy season could result in a longer crop production season, even without hand watering.

If a sufficient quantity of water is available, seven gallons per sq meter will provide one inch of soil water.

IX. Harvesting

Harvesting is the collection of produce from the home garden once it has reache a desired stage of maturity. In a mixed garden, with its numerous crop spe-

cies, harvesting can usually occur daily. A well-balanced diet can be realized through initial good planning and proper crop management.

Two items that require special attention in a home garden are harvesting for maximum nutrition and establishing a living storage unit.

(For a discussion on when to harvest selected vegetables, see Appendix: When to Harvest Vegetables.)

A. Harvesting for maximum nutrition

The major goal of a nutrition-oriented mixed garden is to produce the maximum number of nutritious crops with the least amount of time, space, and expense. Harvesting crops to assure maximum nutritional benefits requires a few basic concepts.

A nutrient will reach its maximum value at a particular stage of growth. In some beans, for example, vitamin C content may be higher in the early fruit development stage, while the protein content is low. At full maturity, however, the protein content is usually highest and the vitamin C content may be decreased.

In addition, different parts of a plant contain different concentrations of nutrients. For example, the sweet potato plant is considered for both its roots and leaves. Most annual crops have more than one part that is edible.

In summary, a crop's most valuable nutrient contribution determines the appropriate time to harvest it.

B. Establishing a living storage unit

A mixture of annuals and perennials provides an opportunity to establish a living storage unit. Generally, bi-annual and perennial crops that have edible leaves and annual root crop plants are in this category. Certain root crop species can be stored in the garden and harvested when needed.

The edible leaves of crops, such as chili pepper, sweet potato, and the drumstick plant, can be harvested daily before meal preparation. Fruit trees which produce over a several month period may be harvested for their fruits as needed.

X. Seed Selection and Storage

Selecting quality seeds and storing them correctly are important activities in assuring a continuation of crop production in the home garden.

A. Seed selection

The first step in selecting seed for the next crop is to determine which crops from the present season are the most pest-resistant, productive, and vigorous. A general rule is to save 50% more seed than is normally needed for planting. Seed selection is in three categories and is done at the end of the crop cycle.

1. Leaf vegetables.

Harvest the seeds when the flowers turn yellow. Dry the pods and remove the seeds by threshing.

2. Legumes

   Allow the seeds to mature on the plant, then harvest and dry them in the sun. Remove seeds from the dried pods.

3. Fruit vegetables.

   Allow them to mature on the plants. Then harvest, remove seeds, and wash the pulp away. Dry them in the sun.

B. Storage

Containers to store seed can be made from home garden crops, such as coconuts, bamboo, and gourds. The seed containers should be thoroughly dried. Wood ash or charcoal are good sources to protect seeds from insects and diseases. Fill one fourth of the container with either material. Place the seeds inside. Seal and shake to spread the ash or charcoal around the seeds. Store in a cool, dry location.

SECTION II: TECHNICAL GUIDELINES

Assessment and Fulfillment of Household Food Needs

Example 1

Nutrition Information

There is a consumption gap in legumes of 65% (40 grams) between the requirement per day (62 grams) and the availability per day (22 grams). That is the equivalent of approximately 5000 grams or 5 kilograms of legumes every four months.

Crop Production Information

The following list indicates local crops, number of days for harvesting, approximate yield in grams/sq meter, and number of sq meters needed by each crop.

Crop	Number Days to Harvest	Approximate Yield (gms/sqm)	Number of Sq Meters Needed
Groundnut	90-120	100	50
Mungbean	70-100	50	100
Lima bean	90-270	300	17
Pigeon pea	90-270	300	17
Cowpea	90-120	300	17
Common bean	90-120	400	8.5
Yardlong bean	70-120	600	12.5

Combining Crop Production and Nutrition Information

The list indicates that yardlong bean, common bean, lima bean, pigeon pea, and cowpea have the highest yield potential. In addition, their young leaves are used as food. Therefore, the area needed to close the legume gap ranges from 8.5 to 17 sq meters per adult every four months. In terms of post-harvest activities, there is light weight change between harvest and the edible portion in legumes.

Production Procedure

A. Supply

Crop inputs needed include seed, poles or trellises, and tools for crop maintenance.

The seed requirement for 20 sq meters of pigeon pea, cowpea, yardlong bean, common bean, and lima bean would be about 20 grams per crop. Beans and peas can usually be procured within the country.

A climbing surface will be necessary for all of the crops except the pigeon pea. Any local wood or tree branch will do fine. Dried bamboo branches are especially good as the vines can spread over the entire surface. Different types of climbing legumes can be planted in the same general area.

A few simple tools are all that is needed to maintain 20 sq meters. A planting stick, watering device, cultivating hoe, and knife are the main tools. These are common in most areas and can be locally procured.

B. Harvest

Within 90 days, most of the legumes are ready for harvest. Some are consumed fresh, such as the yardlong bean, common bean, and lima bean. These can be

picked while still young and tender. Beans and peas which are usually dried should be allowed to mature before picking.

C. Post-harvest

Dried beans and peas do best in a cool, dry storage place. The sprinkling of wood ash can prevent insect and disease damage. The dried seeds can also be used as next season's planting material.

D. Preparation

Legumes should be soaked overnight for preparation the following day. Generally, 1-1/2 cups of cooked legumes should meet the daily protein requirement for an adult.

In summary, it is possible to assess a nutritional deficiency, to determine what land and crops are needed to correct that deficiency, and to pursue crop production and post-harvest activities which will provide foods to eliminate that deficiency.

Example 2

An example of meeting the nutritional deficiencies of an individual adult through home food production for a three-month period:

I. Nutrition Information[1]

Nutrients	Edible Portion per Day (grams)	Recommended Daily Allowance	Gap (%)	Grams (3 months)
Calories	52	60	13	960
Protein	22	62	65	4,800
Pro-Vitamin A	36	55	35	2,280
Vitamin C	23	55	58	3,840

[1]Source: Food and Nutrition Research Institute, Manila, Philippines.

II. Crop Information

Crops		Sq Meter	Number of Plants	Approximate Yield (in grams)
Roots and tubers (calories)				
Sweet potatoes		5	5	10,000
Yam[2]		5	5	10,000
Cassava[2]		5	5	10,000
	Total	15	15	30,000
Legumes (protein)				
Yardlong bean		5	10	6,000
Pigeon pea		5	5	1,500
Cowpea		5	10	3,000
	Total	15	25	10,500
Leaves and Fruits (pro-vitamin A)				
Squash		2	2	2,000
Sweet potato leaves		5	25	3,000
	Total	7	27	5,000
Fruits (vitamin C)				
Tomato		3	6	3,000
Sweet pepper		3	6	2,000
Muskmelon		2	4	2,000
	Total	8	16	7,000

[2]These crops take longer than 120 days to mature.

In a garden of approximately 45 sq meters, it is possible to make up for deficiencies in the major nutrition categories.

SECTION II: TECHNICAL GUIDELINES

Vegetable Characteristics, Adaptation, and Nutritional Value

Sources of nutrition from the home garden

Vitamin A	Vitamin C	Protein
Taro leaves	Papaya (uncooked)	Peanut
Drumstick leaves	Muskmelon	Peas
Bitter melon fruits and leaves	Citrus	Cowpea
Sweet potato leaves	Sugar apple	Mungbean
Cassava leaves	Soursop	Pigeon pea
Squash leaves	Pineapple	Soybean
Hot chili pepper leaves	Guava	Lima bean
Swamp cabbage	Anona	Yardlong bean
Spinach	Mango	Wing bean
Amaranth leaves	Tomato	Yam bean
Carrot	Strawberry	Cacoa bean
Parsley	Cashew (fruit)	Chickpea
Mango (ripe)	Sweet pepper	Watermelon seed
Banana (tundok)		Banana tuber
Papaya (ripe)		Cashew nut
Hibiscus leaves		Pili nut

Energy	Fats and Oils	Iron
Rice	Avocado	Mustard
Corn	Coconut milk	Amaranth
Sweet potato	Pili nut	Green onion
Taro	Peanut	Pechay
Yam	Cacao bean	Spinach
Potato	Cashew nut	Banana heart
Cassava	Soybean	Drumstick leaves
Avocado	Rice bran	Cassava leaves
Coconut (mature)		Sweet potato leaves
Banana		Swamp cabbage
Jackfruit		Dried fruits
Breadfruit		Dried beans
Sugar cane		

SECTION II: TECHNICAL GUIDELINES

Crop Locations in the Home Garden

Plants for wet areas
(near water pump)

- Taro
- Swamp cabbage
- Sugar cane
- Banana

Plants for trellis

- Climbing legumes
  - String bean
  - Lima bean
  - Yardlong bean
  - Wing bean
- Climbing fruit vegetables
  - Squash
  - Gourd
  - Cucumber
  - Bitter melon

Plants for under the trellis

- Taro
- Swamp cabbage
- Sweet potato (for leaves)
- Ginger

Plants for dry areas

- Legumes
- Cassava
- Pineapple
- Tamarind
- Mango
- Sugar apple
- Jackfruit
- Grapes
- Cashew
- Guava
- Soursop

Plants that make good live fences

- Giant ipil-ipil
- Madre de cacao
- Drumstick plant
- Casarina
- Bamboo
- Hibiscus
- Pineapple
- Cassava
- Cactus

Plants that suppress weed growth

- Sweet potato
- Swamp cabbage
- Squash
- Bittermelon

Source: *The UNICEF Home Gardens Hand-Book*

Appendix

to

Nutrition Improvement

through

Mixed Gardening

in the Humid Tropics

A Trainer's Manual

Note: The materials in the Appendix have been adapted from those originally published in the *Agricultural Development Workers Training Manual, Volume III Crops* (Peace Corps, 1982).

Trainees are required to read all the materials in the Appendix and are encouraged to consult as many references as possible.

COMMON UNITS OF MEASURE AND CONVERSIONS

Area

1 HECTARE = 10,000 sq. meters = 2.47 acres = 1.43 manzanas (Central America)

1 ACRE = 4000 sq. meters = 4840 sq. yards = 43,500 sq. ft. =
0.4 hectares = 0.58 manzanas (Central America)

1 MANZANA (Central America) = 10,000 sq. varas = 7000 sq. meters =
8370 sq. yards = 1.73 acres = 0.7 hectares

Length

1 METER = 100 cm = 1000 mm = 39.37" = 3.28 ft.
1 CENTIMETER = 10 mm = 0.4"
1 INCH = 2.54 cm = 25.4 mm
1 VARA (Latin America) = 32.8" = 83.7 cm
1 KILOMETER = 1000 m = 0.625 miles
1 MILE = 1.6 km = 1600 m = 5280 ft.

Weight

1 KILOGRAM = 1000 g = 2.2 lbs. = 35.2 oz.
1 POUND = 16 oz. = 454 g = 0.454 kg
1 OUNCE = 28.4 g
1 METRIC TON = 1000 kg = 2202 lbs.
1 LONG TON = 2240 lbs; 1 SHORT TON = 2000 lbs.
1 QUINTAL = 100 lbs. (Latin America); 112 lbs. (British); 100 kg (metric)

Volume

1 LITER = 1000 cc = 1000 ml = 1.06 U.S. quarts
1 GALLON (U.S.) - 3.78 liters = 3780 cc (ml)
1 FLUID OUNCE = 30 cc (ml) = 2 level tablespoons (measuring type)[1]
= 6 level teaspoons (measuring type)[2]

Miscellaneous Conversions

Lbs./acre x 1.12 = kg/hectare; lbs./acre x 1.73 = lbs./manzana
Kg/hectare x 0.89 = lbs./acre; kg/hectare x 1.54 = lbs./manzana
Lbs./manzana x 0.58 = lbs./acre; lbs./manzana x 0.65 = kg/hectare
Temperature: C° = (F° - 32) X 0.55
F° = (C° x 1.8) + 32

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1. With liquids, 1 level tablespoon equals 18 cc (ml) due to surface tension.

2. 1 level teaspoon (measuring type) = 5 cc with solids; 6 cc with liquids.

UNITS OF MEASURE PRACTICE PROBLEMS

1. 15 acres = _____ HECTARES
2. 5 Hectares = _____ ACRES
3. 8000 M^2 = _____ HECTARES
4. 60 cm = _____ INCHES
5. 1500 mm = _____ INCHES
6. 6 inches = _____ cm
7. 100 km = _____ MILES
8. 40 miles = _____ km
9. 10 meters = _____ FEET
10. 20 feet = _____ METERS
11. 50 kg = _____ LBS.
12. 1000 lbs. = _____ kg
13. 12 ounces = _____ GRAMS
14. 800 g = _____ LBS.
15. 5 gallons = _____ LITERS
16. 10 liters = _____ gallons
17. 10 fl. oz. = _____ cc (ml)
18. 120 cc (ml) = _____ fl. oz.
19. 30°C = _____ °F
20. 100°F = _____ °C

ANSWERS: 1) 6 ha 2) 12.5 acres 3) 0.8 ha 4) 23.6" 5) 60" (59")
6) 15" (15.2) 7) 62.5 miles 8) 64 km 9) 32.8 ft. 10) 6.1 meters
11) 110 lbs. 12) 454 kg 13) 341 g 14) 1.76 lbs (1 lb. 12 oz.)
15) 18.9 liters 16) 2.65 gals. 17) 300 cc. 18) 4 fl. oz.
19) 86°F 20) 37.7°C

SOME "ORGANIC" (NON-CHEMICAL) PEST CONTROLS

CUTWORMS: Place a collar made of cardboard or a paper cup around the stem so that it extends from about 2 cm below the soil surface to about 5 cm above ground. Don't place the collar deeper or you may restrict the root system of the transplant. Wrapping the stem with several layers of newspaper or a couple layers of tin foil works great, too. So do small juice cans or beer cans cut down to the right size. Another cutworm remedy is to tie wild or cultivated onion stems around the stems of susceptible plants at the soil surface.

SLUGS AND SNAILS: Stale beer (or water and yeast) placed in shallow pans in the garden is very effective in attracting and drowning the critters. However, if the container is placed on top of the mulch, slugs are unlikely to reach it. Other remedies are:

1. Place a wide board on the ground in the late afternoon. By the next morning, lots of slugs and snails can be found under it; crush them.

2. Sprinkle coarse sand, wood ashes, lime, or diatomaceous earth around the plant's base to repel the pests. (Caution: too much lime may raise the pH too much.)

3. Keep mulch several inches away from the plant rows; slugs like to hide and feed under it.

4. Keep the field clean of weeds and debris.

ANTS: Pouring boiling water over nests is very effective for fire ants. Steamed bone meal supposedly repels ants. (Don't try making your own bone meal out of old cattle bones; they can harbor dangerous anthrax disease.)

NEMATODES:

1. Crop rotation: Difficult or impractical since most types of nematodes have many crop hosts.

2. Resistant crop varieties: Varieties of a crop will vary in their resistance and some (e.g., Roma VFN and Better Boy VFN tomatoes, Nemagold sweet potatoes, and others) are good enough to rate the name "nematode resistant variety". Check out what's available in your host country.

3. Plowing: Plowing up roots of nematode infested crops right after harvest will expose them to sunlight and drying, which will kill many of the nematodes; however, many are likely to be left in the soil itself.

4. Flooding: One month of flooding followed by a month of drying and a further month of flooding will greatly reduce nematode problems but is seldom practical.

5. Antagonistic plants: Many organic garden books suggest interplanting marigolds among susceptible crops to control nematodes. Unfortunately, research has shown that marigold species vary in their nematode fighting ability which is also limited mainly to certain types of nematodes (root knot, root lesion). Furthermore, nematodes aren't killed by marigolds but only repelled or starved out; this means that interplanting marigolds among susceptible crops isn't effective, since the nematodes still have a food source. You would need to plant marigolds solidly and exclusively for a few months. (See p. 270)

   Two legume green manure or cover crops, Crotalaria spectabilis (showy crotalaria or rattlebox) and Indigofera hirsuta (hairy indigo), can reduce populations of most types of nematodes. Showy crotalaria is poisonous to livestock.

6. Good soil fertility and high organic matter levels help somewhat.

7. Sugar: 8 kg of sugar/sq. meter worked into the top 15 cm of soil is said to control root knot nematodes; this may be worth a try if you're in a low cost sugar area.

COCKROACHES: Mix one pound boric acid crystals with one can of condensed milk (the thick, sugary stuff). Make pea size pellets, place on pieces of tinfoil; use one per room. Will keep a year under refrigeration. Results vary from mediocre to fairly good.

BIRDS: Soaking large seeds like maize in turpentine before planting may be a fair repellant to seed eating birds. An effective method for vegetable gardens and larger plots is continuous string flagging which uses cloth or plastic streamers 5-6 cm wide and 50-60 cm long. The streamers are attached at 1.5 meter intervals to string twine which is strung along heavy stakes at least 1.2 m tall which are spaced about 15 m apart.

CORN EARWORM: Inject 1/4 medicine dropper mineral oil into the tip of each corn ear; begin as soon as silks appear and repeat every 3 days until silks begin to brown.

HAND PICKING: Very feasible for small areas and larger insects like beetles and caterpillars.

INTERPLANTING GARLIC AND ONIONS among other crops to repel insects: Gives poor to sometimes fair control of some insects, but don't rely on it under high insect pressure.

BENEFICIAL PREDATOR INSECTS: Lady bugs, lacewing bugs, tachnid flies, braconid wasps, praying mantids are among the more common. Where they occur naturally, they can make a big contribution. Introducing them is seldom effective, since they tend to disperse.

BIOLOGICAL INSECTICIDES

1. Bacillus thruingiensis (Dipel, Thuricide, Biotrol): Made from a natural bacteria that kills many types of caterpillars, such as cabbageworms, earworms, armyworms, and hornworms. Non-toxic to humans and animals. Slow acting--insects don't die immediately but stop feeding within a few hours; apply while they're still young for best results.

2. Bacillus popillae: When applied to the soil, causes milky spore disease in Japanese beetle grubs and some other beetle grubs.

HOMEMADE ORGANIC SPRAYS

All of them except nicotine spray (which isn't really "organic") will only repel some types of insects to varying degrees and may need daily application.

Bug Juice Spray: You need a strong stomach for this one, and it's of fickle effectiveness. Collect up to half a cup of a bad guy insects like cabbage loopers, stinkbugs, etc. Add 2 cups of water, place in a blender, and whiz it up. Organic Gardening says this solution can be diluted up to 1:25,000 but that sounds like a misprint! Try it 1:5 or 1:10 for starters. Use it within an hour or two or freeze it to prevent possible contamination by Salmonella bacteria (food poisoning). Clean your blender well. In some cases, bug juice actually attracts insects; cutworm juice is known to attract cutworms. Some success has been reported with aphids, cabbage loopers, and stinkbugs plus a few more. Don't use flies, ticks, fleas, or mosquitos since they may harbor diseases or parasites.

Plant Juice Spray: Find a non-poisonous weed or plant leaf unbothered by insects; choose smooth leaf plants, not hairy ones, and then dilute no more than 5 fold with water. Wormwood is said to kill slugs, crickets, and aphids.

Hot Pepper Spray: Grind hot pepper pods and mix with an equal amount of water. Add a little soap powder. Try it at a 1:20-1:30 dilution with water. Be sure to strain it well before putting it in the sprayer tank.

Garlic-Pepper-Soap Spray: 4 crushed garlic cloves, 4 tablespoons hot pepper, one cake of strong soap, one cup of hot water. Strain and dissolve in 2-4 gallons warm water. Use as a general purpose spray. Results are variable.

Citrus and Banana Peel Spray: Let banana and citrus peels soak in a pail for several days. Spray the mixture on plants and place the spent peels at their base.

Milk Spray: Using milk full strength is deadly to many bugs but what a waste of protein! By the way, it's been shown that dipping one's hands periodically in milk or a powdered milk solution when transplanting tomatoes can significantly cut down the spread of mosaic virus.

Salt Spray: A tablespoon in 2 gallons of water supposedly gives fair to good control of cabbage worms; 2 tablespoons/gallon supposedly controls spider mites but test a plant or two for leaf burn first with the spray.

Molasses spray: Diluted 1:50 with water and used as a general purpose spray. Sounds doubtful.

Vegetable oil; Apply with a sprayer; may kill insects by plugging up their pores.

Soap spray: For soft bodied insects like aphids, thrips, whiteflies, mites, but not leafhoppers. Vegetable or plant derived soaps are better for this than petroleum derived ones.

Nicotine Extract: For sucking insects like aphids, leafhoppers, whiteflies, thrips, and spider mites along with many non-suckers. Most effective during warm weather. Soak 1-2 cheap shredded cigars overnite in 1 gallon water. Strain and add one teaspoon of household detergent. CAUTION: Nicotine is poisonous to humans and animals; it can be absorbed through the skin in harmful amounts. It can also spread tobacco mosaic virus to tomatoes, peppers, eggplant, and potatoes.

MISCELLANEOUS

Flour: Sprinkle on cabbage plants in early morning when dew is heavy. Supposedly controls cabbageworms and their moths by sticking to them and then hardening as it dries out.

Wood ashes: May repel some types of insects if sprinkled on plants; if spread in a ring around plants and moistened, they may repel cutworms.

DISEASE CONTROL

I. TYPES OF DISEASES AND THEIR IDENTIFICATION

Parasitic vs. Non-parasitic Diseases

Parasitic diseases are caused by certain types of fungi, bacteria, and viruses that invade plants and multiply within their tissues. Nematodes and parasitic weeds like Striga (witchweed) can also be included in this category, but we'll deal with them separately below.

Non-parasitic (non-infectious) diseases are caused by unfavorable growing conditions or other non-parasitic factors such as:

a. Excesses, deficiencies, or imbalances of soil nutrients.

b. Excessive soil acidity or alkalinity.

c. Temperature extremes.

d. Poor drainage or drought.

e. Mechanical, fertilizer, or pesticide injury.

f. Air pollutants like ozone and sulfur dioxide.

Some of these non-parasitic conditions produce symptoms easily confused with those of parasitic diseases.

Fungal Diseases

Fungi are actually tiny parasitic plants without roots, leaves, or chlorophyll which feed on living or decaying organic matter; they reproduce and spread by means of microscopic seeds called spores. Some fungi are beneficial such as those that help break down crop residues into humus; others are harmful, penetrating directly into seed, leaf, or root tissue or entering through wounds or natural openings.

General types of fungal diseases: Leaf spots leading to possible defoliation; rotting of seeds, stems, stalks, roots, grain heads, pods, and ears; storage molds; wilts.

Diseases caused by fungi are by far the most common, because the spores are highly resistant to unfavorable conditions. They are easily spread by wind, water, soil, and farm implements, but some types can also be carried by the crop seeds themselves. Most fungal diseases develop and spread much more readily under high humidity and moisture. An important characteristic of fungal diseases is their ability to mutate to produce new races that are resistant to certain fungicides; this is not common, however.

Bacterial Diseases

Bacteria are microscopic single cell organisms that multiply by cell division. Like the fungi, some bacteria are beneficial and perform essen-

tial functions like converting unavailable organic forms of soil nutrients to available inorganic (mineral) forms. Others invade plants and cause diseases that produce leaf spots, wilts, galls, and fruit and stem rots.

Bacterial diseases are generally much less prevalent than fungal diseases because

a. Bacteria lack a resistant spore stage and are very dependent on favorable temperature and moisture conditions.

b. Unlike the fungi, bacteria can't forcibly penetrate into plant tissue but must enter through natural openings or wounds.

c. Although bacterial diseases can be spread by wind driven rain, field equipment, and certain types of insects (mainly some beetles), they are much less readily transmitted than fungal diseases.

Viral Diseases

Viruses are microscopic particles consisting of a core of nucleic acid (genetic material) surrounded by a protein coat. Viruses can multiply by diverting living host cells into the production of more virus particles and can also mutate to produce different strains. They are largely spread by sucking insects (aphids, leafhoppers, thrips). The relationship between these insect vectors and the viruses is sometimes very specific; for example, peanut rosette virus is transmitted by only one species of aphid. Some species of weeds are susceptible to certain viruses and serve as alternate hosts to provide sucking insects with a steady source of innoculum.

Viruses usually don't kill plants but can greatly reduce yields and quality. A wide variety of symptoms are produced such as leaf mottling (blotching), leaf curling, chlorotic (yellow) or necrotic (dead) spots on the leaves, leaf malformation, leaf striping, and excessive branching.

How to Identify Plant Diseases

Some plant diseases can be readily identified by non-professionals right in the field; in other cases, however, accurate diagnosis requires a good deal of field experience, the expertise of a trained plant pathologist, and lab facilities.

Troubleshooting Disease Problems

Helpful items: Magnifying glass, pocket knife for slitting stems, pictorial disease identification guides (see below).

1. Symptoms of some fungal, bacterial, and viral diseases can be easily confused with each other or with those caused by nematodes, non-parasitic diseases, or insects.

2. Examine the plants closely. If root, stem, or stalk rots are suspected, carefully remove some plants from the soil along with part of the root system; look for signs of damage such as soil insects,

root feeding, root discoloration. Slit stems and stalks lengthwise and check for rotting, discoloration or borers.

Disease Identification Guides for the Reference Crops

This section gives verbal descriptions of common reference crop diseases, but pictures are definitely worth a thousand words when it comes to identification. Ag field workers will find the following pictorial disease guides invaluable:

Maize

"Maize Diseases: A Guide for Field Identification", Information Bulletin No. 11, CIMMYT, Londres 40, Apartado Postal 6-641, Mexico 6, D.F. Available in English and Spanish.

"A Compendium of Corn Diseases", American Phytopathological Society, 3340 Pilot Knob Rd., St. Paul, Minnesota, U.S.A. 55121. More complete than the CIMMYT bulletin and also gives some control measures.

Sorghum and Millet

"Sorghum and Pearl Millet Disease Identification Handbook", Information Bulletin No. 2, ICRISAT, P.O. Patancheru 502 324, Andhra Pradesh, INDIA or Texas Agricultural Experiment Station, Texas A & M Univ., College Station, Texas, U.S.A. 77843. Available in English, French, Spanish.

"Sorghum Diseases", Bulletin 1085, Texas Agricultural Extension Service, Texas A & M Univ., College Station, Texas, U.S.A. 77843. Also gives some control measures.

Beans

"Field Problems of Beans in Latin America", CIAT, Apartado Aereo 6713, Cali, COLOMBIA, S.A. $5.60 (U.S.) plus postage. Includes diseases, insects, and hunger signs. Available in English and Spanish. Also gives some control measures.

"Bean Diseases: How to Control Them", Agriculture Handbook No. 225, Agric. Research Service, U.S.D.A. Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. Not as complete as the CIAT bulletin.

Soybeans

"Soybean Diseases Atlas", Cooperative Extension Service, Clemson University, Clemson, South Carolina, U.S.A. 29631.

"Soybean Insects, Nematodes, and Diseases", Circular 504, Cooperative Ext. Service, Clemson Univ., Clemson, South Carolina, U.S.A. 29631.

II. METHODS OF DISEASE CONTROL AND THEIR EFFECTIVENESS

Prevention vs. Cure

Most diseases such as viruses and the bacterial and fungal rots of seeds, seedlings, roots, stalks, and stems can't be controlled once they enter plant tissue. Fair to good control of fungal leafspots* can be achieved with foliar fungicides but this is usually uneconomical with low value crops like maize, millet, and sorghum. Disease control methods are therefore geared much more toward prevention rather than cure. Let's look at the principal non-chemical and chemical control practices.

Non-Chemical Disease Control Methods

1. Resistant varieties: Plant breeders have located genetic sources of resistance to some of the more serious diseases, especially viruses and other types that lack effective or economical chemical control measures. However, resistance does not mean 100% immunity, and the ability of viruses and fungi to mutate into new races has posed some problems. Disease resistance is a top priority among plant breeders.

2. Sanitation and Cultural Practices

   a. Disease free seed: Some diseases like bacterial blight and common mosaic virus of beans can be carried by the seeds. The use of certified seed (see Section C) that is disease free is an important management practice in many bean growing areas where these problems exist.

   b. Controlling host plants and insect vectors: This is especially important for controlling certain viral diseases and involves the removal of host weeds and other natural vegetation that serve as sources of innoculum. In some cases, non-susceptible barrier crops are planted around a field in a 15-20 meter wide strip to "decontaminate" sucking insects before they reach the susceptible crop (this is usually not practical). Also included is the roguing (removal) of diseased crop plants attacked by viruses; roguing is not effective for most fungal and bacterial diseases.

   c. Crop residue management: The burning or plowing under of crop residues is an effective prevention method for a few diseases like peanut Southern (Sclerotium) stem rot.

   d. The following practices may help minimize certain disease problems: not cultivating plants while they are wet; avoiding crop injury at or before harvest; irrigating in the morning when sprinklers or hand watering are used so that crop leaves

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* Fair control of most bacterial leaf spots can be obtained using copper base fungicides.

are dry at night; using raised beds to improve drainage; disinfecting tools.

e. Crop rotation can reduce the incidence of many fungal and bacterial diseases,* especially those that are soil borne, but will have little effect on viruses. There is nothing wrong monoculture from a disease standpoint as long as resistant varieties are being continually developed and introduced in response to new problems; however, this is unlikely in the LDC's.

f. Intercropping may reduce or intensify disease problems, depending on the crop mixtures involved and whether they share some diseases in common.

Chemical Disease Control Methods

1. Fungicides can be applied to planting seeds, soil, and crop leaves and will provide fair to good control of certain fungal diseases. They are mainly applied as protectants.

   a. Seed treatment with a fungicide dust or liquid will effectively prevent seed rots (pre-emergence "damping off") caused by soil fungi and will also kill any fungal diseases borne on the seedcoat surface such as loose smut and covered smut which attack adult sorphum plants.

      Since seed treatments mainly protect the seed, they are not as effective at preventing seedling blights (rots) and seedling root rots. A systemic seed treatment fungicide called Vitamax (Carboxin) gives somewhat better control.

      Seed treatments will not control any soil-borne or airborne fungal diseases that attack older plants such as leaf spots, stalk rots, stem rots, and root rots.

   b. Fungicide applications to the soil: Some fungicides like PCNB (Terrachlor), Vitavax (Carboxin), and Benlate (benomyl) can be applied as sprays or dusts to the seed furrow or to the row soil during crop growth to control certain fungal stem and root rots.

      Such soil applications are seldom necessary or economical for maize, sorghum, and millet but are usually profitable on high yielding peanut and bean crops if such disease problems exist.

   c. Foliar fungicides can be applied as dusts or sprays to crop foliage to control fungal leaf spot diseases. Most foliar fungicides act as protectants to help prevent the occurrence or spread of leaf spots. Some of the recently developed systemic

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* Especially soil-borne ones.

fungicides like Benlate (benomyl) and Mertect (Thiabendazole) also have erradicant properties.

Most foliar fungicides have little or no activity against bacterial leaf spots, but copper base fungicides provide fair to good control.

Foliar fungicides are usually not economical for field crops like maize, sorghum, and millet but are often essential for control of Cercospora leaf spot in peanuts and can be very profitable in this case. Their use on beans may be justified where yields are in the medium to high range and fungal leaf spots become serious. The use of foliar fungicides on high value vegetable crops such as tomatoes, squash, and potatoes is usually very cost effective where foliar fungus diseases are a problem.

2. Soil sterilants like methyl bromide, formaldehyde, Basamid, and Vapam will control soil fungi, bacteria, insects, weeds, and nematodes. They are applied in advance of planting and allowed to dissipate before the seeds are sown. Soil sterilants are frequently used on seedbeds for growing tobacco and vegetable transplants but are too expensive for use with the reference field crops.

3. Antibiotics like Streptomycin and Terramycin are bactericides used as foliar sprays or transplant dips to control certain bacterial diseases. Other antibiotics like Kasumin (Kasugamycin) and Blasticidin are effective against certain fungal diseases such as rice blast and are widely used in Japan. Their high cost makes them uneconomical for use on the reference crops. There are several problems associated with antibiotics, namely residues, the development of resistant races of fungi and bacteria, and occasional phytotoxicity (plant injury).

4. Use of insecticides to control insect vectors: This is seldom completely effective since 100% control is impossible.

Integrated Disease Control

Integrated disease control involves the combined use of non-chemical and chemical methods. Except for the mercury base fungicides sometimes used as seed dressings, the fungicides pose few toxic or environmental threats, unlike some insecticides. The main impetus for integrated disease control is based on economics and the fact that many diseases cannot be adequately controlled with chemicals.

RECOMMENDATIONS FOR FOLIAR FUNGICIDES

Protectant vs. Erradicant Fungicides

Most fungicides like Maneb, Zineb, Difolatan, and Manzate act as protectants: by remaining on the leaf surface to prevent fungal spores from germinating and penetrating the plant; they have little or no erradicant

ability to stop the progress of an existing infection. However, a few fungicides like Benlate (benomyl) and Thiabendazole (Mertect) are actually absorbed into the leaf tissue and translocated outwards toward the margins; these systemic fungicides act as erradicants as well as protectants and also have other advantages:

1. They are not vulnerable to being washed off the foliage by rainfall or sprinkler irrigation.

2. Since they are translocated within the leaf, uniform foliage coverage isn't as important as with the non-systemic protectant fungicides.

The main disadvantage of the systemic fungicides is that they are effective against a narrower range of fungal diseases than most of the protectant fungicides, so more care must be taken to match the product to the disease. Another problem is that a few fungal diseases have developed resistance to some of the systemics (this hasn't occurred with the non-systemics).

Guidelines for Applying Foliar Fungicides

Type of Crop: Foliar fungicides are seldom economical for maize, sorghum, and millet; they will give the best benefit/cost ratio (cost-effectiveness) when used on well managed peanuts and beans under conditions where fungal leaf diseases are a limiting factor and on high value vegetable crops.

When to apply: Ideally, applications should be started slightly before the onset of infection or at least before the disease signs have become very evident. This is especially important when non-systemic protectant fungicides are used. In most growing areas, the major fungal leaf diseases are often rather predictable as to their date of first appearance, so that preventative applications can be begun in advance. Fungicides are too expensive to be used on a routine basis from the time the plants emerge; besides, most fungal diseases don't infect plants until around flowering time or after.

Frequency of application: This depends on disease severity, rainfall, and type of fungicide. The non-systemic protectant fungicides can be washed off the foliage by rainfall (or sprinkler irrigation), but the systemics remain safely within the plant once they've been absorbed. Under frequent rainfall, the protectants may have to be applied as often as every 4-7 days. Under less wet conditions, intervals of 10-14 days regardless of rainfall frequency. Disease severity also affects application frequency but is usually closely related to rainfall and humidity (as well as varietal resistance).

Uniform and thorough coverage of crop foliage is very important when applying fungicides. This is especially true for the protectant products which are effective only on those portions of the leaf surface they actually cover. An attempt should be made to cover both sides of the leaves when using protectants. Stickers and spreaders (see pp 233-234) are recommended for nearly all fungicide sprays to enhance coverage and adhesion; Duter is one exception, since these additives increase the likelihood of crop injury from that particular product. Some fungicides already contain stickers and spreader, so be sure to read the label.

Amount of water needed for adequate foliage coverage: This varies with plant size, crop density, and type of sprayer. When using backpack (knapsack) sprayers on full size plants, at least 700 liters/ha (75 gals./acre) of water is needed. Excessive water volume increases runoff which carries away spray droplets.

Nozzle selection and sprayer operation: See insecticide section.

Dosage Recommendations

Always follow label instructions and the recommendations of your country's extension service if the latter are based on sound adaptive research. The following recommendations are meant to serve as general guidelines.

Peanut Cercospora Leafspot: Benlate and Duter have generally proved the most effective although most other products such as Dithane M-45, Antracol, Bravo (Daconil), Difolatan, copper-sulfur dusts, and copper base sprays also give satisfactory control. The following recommendations come from North Carolina State University (U.S.A.) and Australia.

Duter 47% WP, 425 grams actual formulation per hectare (6 ounces/acre); don't use a sticker or a spreader.

Benlate 50% WP, 285 grams actual formulation/ha (4 oz./acre) plus sticker-spreader. Control is enhanced by combining 285 grams Benlate + 1.7 kg Dithane M-45 or Manzate 200 + 2.3 liters non-phytotoxic crop oil per hectare; the oil improves penetration.

COMMON FOLIAR FUNGICIDES

They are of relatively low toxicity (compared to insecticides) and have minimal dermal absorption (the dermal LD_{50} for Captan is over 10,000).

ANTRACOL (Propineb): Not registered in the U.S., but widely used overseas. A zinc base product by Bayer. Especially effective against early and late blight. Compatible with most other pesticides. Use at 75-125 cc per 15 liters (5-8 tablespoons per 4 gallons) and apply at 4-10 intervals depending on weather and disease severity.

BENLATE (Benomyl): One of the few systemic fungicides; has an erradicant effect as well as a protective effect but it is not broad sprectrum; mainly for powdery mildews, Cercospora leafspot (peanuts), Botrytis (Gray mold) of tomatoes and lettuce, and brown rot of fruit trees. For small areas, use 1-2 teaspoonfuls per gallon (5-10 cc/gal.). Also prevents mite eggs from hatching. Repeat at 10-21 day intervals. Use a sticker-spreader.

BORDEAUX (Copper sulfate + hydrated lime + water): One of the first original manmade fungicides. Has a protectant effect and also repels some insects. Don't let the solution stand in the sprayer for long periods. You can make it yourself. Two common formulas are 8-8-100

and 10-10-100 (first 2 numbers refer to lbs. of copper sulfate and hydrated lime; the last number refers to gallons of water). Each lb. of copper sulfate in 100 gals. of water equals 1/3 tablespoon (5 cc) per gallon. Each lb. of hydrated lime (slaked lime or calcium hydroxide) per 100 gals. equals 1 tablespoon (15 cc)/gal. To make 1 gallon of the 8-8-100 formula, dissolve 40 cc copper sulfate in 1/2 gal. of water; then dissolve 120 cc of hydrated lime in the other 1/2 gal; then mix both together. May cause leaf burn if made too strong.

CAPTAN (Orthocide, Merpan): Very safe broad-spectrum fungicide (also for seed treatment). Use the 50% WP at 3.5-5 tablespoons per gallon (13-20 cc/liter). As a seedbed drench for damping off prevention, mix up 2-3 cc/liter of water and apply with a sprinkling can at the rate of 2-3 liters/sq. meter immediately after planting vegetables (if seed is not treated) or as soon as the seedling emerge.

COPPER COMPOUNDS (Aside from Bordeaux): For broad-spectrum foliar fungal control, but also more effective than other types for bacterial leafspots. Don't mix these with Diazinon insecticide. Copper oxyxhloride and Cupravit Blue are two examples and are used at 400-600 grams/100 liters water.

DACONIL (Bravo W-75, Termil): Broad-spectrum foliar fungal control; toxic to fish. Compatible with most other fungicides. Don't apply within 5 days of harvest. Use at 2.5-3 tablespoons per gallon (10-12 cc/liter).

DUTER (fentin hydroxide): An organic tin compound used on potatoes for its unusually good control of early and late blights. Also widely used for Cercospora leafspot on peanuts. Has some insect anti-feeding properties. Do not use a sticker-spreader or leaf burn may result.

MANEB (Dithane M-22, Manzate 200, Lonocol M): Manganese base broad-spectrum fungicide available as an 80% WP. Used at 1.5-2.5 tablespoons/gal. (6-8 g/l) or 1.5-2.5 lbs./100 gals. Don't apply within 5 days of harvest.

MANZATE (Dithane M-45, Mancozeb, Fore): A manganese-zinc combination. Manufacturers claim it's better than Maneb on tomatoes. Use same dosage as for Maneb. Don't apply within 5 days of harvest. Also used as a seed piece dip on potatoes to control seed piece decay.

ZINEB (Dithane Z-78, Lonocol Z, Polyram Z): A zinc base product. May injure squash and cucumber and tobacco. Don't apply within 5 days of harvest. Use same dosage as for Maneb.

PCNB (Terrachlor, Brassicol): A soil fungicide usually applied preplant either broadcast or in a band; also used as a soil drench at transplant time. Mainly for damping-off, Sclerotinia, and Rhizoctonia. For cabbage family crops, it's used as a seedbed drench right after planting. Use 1 tablespoon Terrachlor 75W + 2 tablespoons Captan 50W per gal. of water and apply it over 50 sq. ft.

FUNGICIDES FOR SEED TREATMENT

Remember that treating seed with a fungicide inhibits surface-borne fungi on the seed coat and protects against soil-borne ones. Most fungicide seed treatments offer no protection to the seedling. However, some of the newer systemic fungicides for seed treatment such as Vitavax (carboxin) can offer some protection during the early stages of seedling growth. Seed treatment will not control any soil-borne or airborne fungal diseases that attack older plants like leaf spots, stalk rots, root rots, etc.

ARASAN (Thiram, Tersan): A low toxicity compound usually available as a 50% or 75% dust.

BENLATE T (Thiram + Benlate): For control of soil-borne Pythium, Fusarium, Rhizoctonia damping off and early root rots of beans and peas. Benlate (benomyl) is a systemic. Low toxicity.

CAPTAN (Orthocide, Merpan): Another low toxicity seed treatment fungicide that's also used as a foliar fungicide.

FERNASAN: A combination of Arasan and Lindane (an insecticide) that comes in several formulations. Fernasan 75W contains 75% Arasan and 1% Lindane--only enough insecticide to protect seeds during storage, not once in the ground. Fernasan 60/15 contains 60% Arasan and 15% Lindane for better control of seed eating insects in the soil. Both formulations are used at rates of 100-150 grams per 100 kg of seed. Smaller seeds require the higher dosage (more surface area).

MERCURY COMPOUNDS: Mercury compounds have been virtually banned in the U.S. as seed treatments. The problem wasn't a build-up of mercury in the soil but the accidental (or unwitting) ingestion of mercury treated seed by livestock or even people. Mercury is very effective and even has a penetrating effect into the seed, but avoid using it whenever possible. Common mercury-base seed treatment compounds are Ceresan and Semesan. Agallol is a mercury base dip for potato seed pieces, but Zineb or Manzate can be substituted. Skin absorption of organic mercury compounds (Ceresan, Semesan, Agallol) is minor but not so with inorganic compounds like bichloride of mercury. Avoid breathing the vapors of any mercury product.

APPLYING SEED TREATMENTS: Arasan, Captan, and Fernasan can be applied as dusts to the seed at the rate of about 2-3.5 grams per kg of seed (smaller seeds need the higher rate). A baby food jar works perfectly for small quantities of vegetable seeds and you can "eyeball" the rate (it takes much less than you think); seed should be uniformly covered but not "buried" in the fungicide. Wash hands afterwards. Always store treated seed out of reach of children and NEVER feed leftovers (e.g., treated maize, sorghum, bean seed, etc.) to humans or animals.

NEMATODES AND THEIR CONTROL

I. BASIC FACTS ON NEMATODES

What are nematodes?: They are tiny, colorless, threadlike, unsegmented roundworms; they are not related to earthworms. Some types of nematodes like hookworms, roundworms, and pinworms attack man as well as animals. There are several dozen species that attack plant roots as well as a few that injure stems and leaves. These plant feeding nematodes live in the soil, and most are too small (0.2 - 0.4 mm) to be easily seen with the naked eye.

How do they damage plants?: The root feeding nematodes are the most common types attacking plants. They feed on or inside plant roots using needle-like mouthparts (called stylets) for piercing and sucking. The root knot nematode causes portions of the roots to swell into galls or knots, while root lesion nematodes produce dark colored lesions on the roots. Sting nematodes and stubby root nematodes prune the root system, making it appear stubby and sparse. Affected plants have trouble absorbing enough water and nutrients and become much more vulnerable to soil-borne fungal and bacterial diseases. In fact, those tomato varieties resistant to Fusarium wilt lose that resistance when attacked by nematodes.

How serious is the damage?: Heavy infestations can lower crop yields by 30-80%.

Where are nematodes found?: Nematodes can be found in virtually any soil but are most prevalent and active where soil temperatures are warm; they seem to prefer sandier soils or those portions where moisture and soil fertility are low.

How do nematodes spread?: Nematodes reproduce by eggs, and life cycles of some types can be as short as 18-21 days in warm soils. Although a typical nematode will move less than half a meter during its life, they are easily spread by soil carried on tools, feet, and transplants or by water runoff from a field.

What crops are most affected?: Nearly all crops are susceptible to some type of nematode but vegetables and pulse crops are generally more vulnerable than cereal crops.

Some crops especially susceptible to root knot nematode damage: Squash, cucumber, watermelon, cantaloupe, tomato, pepper, beans, peas, okra, lettuce, carrots, and strawberries.

Some crops especially susceptible to root lesion nematodes: Okra, pepper, potato, sweetpotato, strawberries, cowpeas, peanuts, soybeans.

Varieties within a crop vary greatly in their resistance to different types of nematodes.

II. HOW TO DIAGNOSE NEMATODE PROBLEMS

Nematode damage is not often obvious or easily differentiated from other problems. In fact, a lab analysis is usually needed to confirm nematode damage and the type of nematode, except in obvious cases of root knot nematode infestation.

Above Ground Symptoms

Above ground symptoms aren't distinctive enough to make a conclusive diagnosis without also examining the root system, but the following are possible indications of nematode damage.

1. Plant stunting and lack of vigor is the most common but can also be caused by other problems such as low soil fertility, lack of moisture, diseases, insects, etc.

2. Yellowing of the leaves is another symptom, although diseases, some hunger signs, insects, moisture stress, etc., can also cause yellow leaves.

3. Wilting, even when soil moisture appears adequate and heat isn't excessive; however, soil insects, stem borers, and diseaes can also cause wilting.

4. Scattered patches are a distinguishing feature of nematode damage; rarely is it uniform.

Root Symptoms

Carefully dig up the roots and look for the following:

1. Galls or knots on roots indicate root knot nematode damage. Don't confuse them with Rhisobia bacteria nodules attached to legume roots. Nematode galls are swellings of the actual root itself and have a white, granular appearance inside. Rhizobia nodules are pink to red inside and can be easily detached from the roots.

2. Root damage by other species is less obvious and takes the form of dark colored lesions (wounds), stubby roots, and general stunting of the root system. Don't confuse these symptoms with those caused by rootworms, white grubs, or other soil insects.

Laboratory Diagnosis

Plant pathology labs in most countries can test soil and root samples for nematodes. Take 5-10 random sub-samples within the field right next to plants, using a shovel. Dig down about 20-25 cm (8-10") and discard the soil from the top 5 cm and from the sides of the shovel. Place the remaining 15-20 cm deep strip in a pail, and be sure to include some roots. Mix the sub-samples together and place about a half-liter (pint) of the soil into a plastic bag. Protect the sample from sunlight and exposure to excessive heat. Fill out the lab's information form completely.

INTRODUCTION TO INSECTS AND INSECT CONTROL

I. SOME IMPORTANT FACTS ON INSECTS

How Insects Damage Plants

Insects can often be identified by the type of damage they cause:

1. Chewing and Boring Insects

   a. Caterpillars are larvae of moths. They damage plants by feeding on leaves and making holes in them or by boring into stalks, pods, and maize ears. The cutworm caterpillar is unusual in that it lives in the soil and emerges at night to cut off plant stems near ground level.

   b. Beetles feed on plant leaves and chew holes in them; some beetles of the weevil family bore into pods and seeds and deposit eggs inside. Certain beetles can also transmit bacterial and virus diseases.

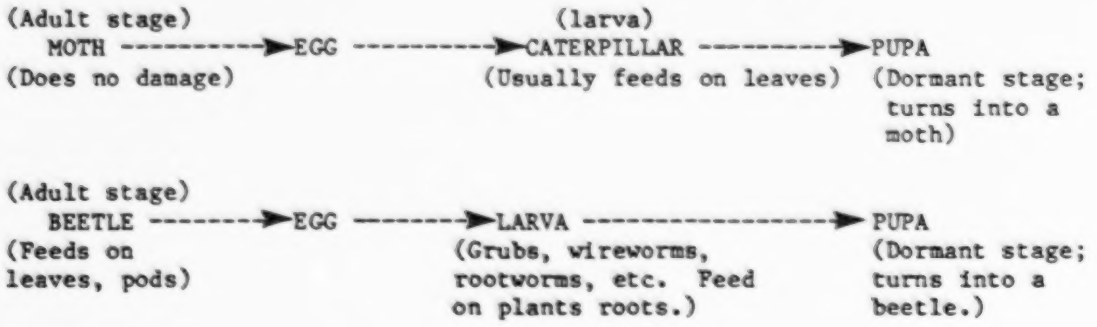
   c. Most beetle larvae like white grubs, wireworms, and rootworms live in the soil and damage roots and the underground portion of the stem by chewing or boring. A few beetle larvae such as those of the Mexican bean beetle and Colorado potato beetle live above ground and feed on leaves.

2. Sucking Insects

   Aphids, leafhoppers, stinkbugs, harlequin bugs, whiteflies, and mites have piercing and sucking mouthparts and feed on plant sap from leaves, pods, and stems. They transmit a number of plant diseases, especially viruses. Sucking insects do not make holes in the leaves but usually cause leaf yellowing, curling, or crinkling.

Insect Life Cycles

A general understanding of insect life cycles will also help you identify insect problems in the field. Beetles and moths go through a complete metamorphosis (changes in form) of 4 stages, while aphids, leafhoppers, whiteflies and other sucking insects go through only 3 stages.



(Adult stage)
APHIDS, LEAFHOPPERS, STINKBUGS, WHITEFLIES, OTHER SUCKING INSECTS ---------➤ EGG ---------➤ NYMPH (Looks like a miniature adult; sucks sap also; turns into the adult stage.)

II. HOW TO IDENTIFY INSECTS AND THEIR DAMAGE

1. BE OBSERVANT! Troubleshooting takes practice, but a sharp eye is essential. When walking through a field, closely examine the plants for insects or their damage symptoms. Check both sides of the leaves since many insects prefer the undersides of leaves. A magnifying glass can be very helpful.

2. Identifying Insect Damage: Very often you'll be able to identify insects by the damage they cause.

   a. Holes in leaves: Caterpillars, beetles, crickets, snails, and slugs; snails and slugs aren't insects but do attack plant foliage (look for slime trails on leaves). Caterpillars leave green or brown sawdust-like excrement.

   b. Wilting: Soil insects like white grubs and wireworms if root feeding or tunneling of the underground portion of the stem has been serious; stem borers. Remember that wilting can be caused by other factors too: dry soil, very high temperatures, root rots, bacterial and fungal wilts, and nematodes.

      (1) Dig up the affected plants and check the root system and underground portion of the stem for insect and disease damage; look for soil insects.

      (2) Slit the stem lengthwise with a pocket knife and check for borers or rotted tissue.

   c. Leaf curling, crinkling, or yellowing: Sucking insects, especially aphids, leafhoppers, and mites. Viruses and some nutrient deficiences also produce these symptoms. Nematodes and poor drainage cause yellowing too.

3. Identifying Insects: Spend time with locally experienced extension workers in the field and have them point out the prevalent crop insect pests (and beneficial predator insects) in your work area. Seek out host country or regional insect guides such as extension bulletins. The publications listed below are also very useful:

   Insect Pests, a Golden Guide, Geo. Fichter, Golden Press, New York. Available from Dept. M, Western Publishing Co., 1220 Mound Ave.,

Racine Wisconsin, U.S.A. 53404. $1.95 plus postage. A good general guide that includes many insects with their scientific and common names.

Agricultural Pests of the Tropics and Their Control, D. Hill, Cambridge University Press, London, 1975.

Field Problems of Beans in Latin America, CIAT, Apdo. Aereo 6713, Cali, COLOMBIA. $5.60 plus postage.

III. THE USE OF SCIENTIFIC NAMES FOR INSECTS

Each insect is known by many different local names throughout the world, which can make proper identification confusing. Fortunately, all insects (as well as plants, animals, and diseases) are assigned standardized scientific names derived from Latin.

Example: The corn earworm has been given the scientific names of Heliothis zea. The first word of the two part name refers to the insect's genus and the second part of its species.

Host country agronomists and extension workers may often refer to insects using their genus such as "heliothis". Farmers will usually use local names for insects. Since this genus-species is being continually revised, an insect may have more than one commonly used scientific name; for example, the fall armyworm has had its scientific name changed from Laphygma frugiperda to Spodoptera frugiperda. When referring to several insects of different species that are all within the same genus, publications will often place the abbreviation "spp." after the genus. Thus, Heliothis spp. refers to several types of heliothis caterpillars.

IV. METHODS OF INSECT CONTROL AND THEIR EFFECTIVENESS

Let's compare the effectiveness of non-chemical, chemical, and integrated insect control methods:

NON-CHEMICAL METHODS

Natural Balance

Many natural controls act to keep insects in balance:

1. Weather factors like temperature and rainfall can restrict the distribution of an insect species; for example, mites and leafhoppers are usually more prevalent under dry conditions.

2. Geographic barriers like large bodies of water, mountains, and deserts can also limit insect distribution.

3. Frogs, toads, lizards, moles, and birds are some of the many animals that feed largely on insects.

4. Beneficial predator insects like lady bugs feed on aphids, while others like the braconid wasp and tachinid fly lay eggs on or i-

certain pests which are killed by the developing larvae. However, some predator insects, e.g., praying mantis, also eat beneficial insects.

5. Insects are also attacked by viruses, fungi, and bacteria which help keep populations down.

As agricultural activities have increased, many of these natural balances have been upset and can no longer be relied upon to keep harmful insects under control. Monoculture and the existence of vast areas under cropping have led to marked increases in a number of insect pests. Many of the traditional crop varieties, despite their lower productivity, have better insect resistance than some of the improved varieties. Indiscriminate use of pesticides has also resulted in an actual buildup of harmful insects in some cases.

Biological Control

Biological control is the purposeful introduction of predators, parasites, or diseases to combat a harmful insect species. About 120 different insects have been partially or completely controlled by this method in various parts of the world. Microbial insecticides such as Bacillus thuringiensis (effective against a few types of caterpillars) are now commonly used by farmers and gardeners in many areas. Unfortunately, biological control measures are presently effective against a very small portion of harmful insect species.

Cultural controls

Cultural controls such as crop rotation, intercropping, burying crop residues, timing the crop calendar to avoid certain insects, and controlling weeds and natural vegetation that harbor insects are all effective control methods for some insects. In most cases, however, cultural controls need to be supplemented by other methods.

Varietal Resistance

Crop varieties vary considerably in their resistance to certain insects. For example, maize varieties whose ears have long, tight husks show good resistance to earworms and weevils. CIAT found that some bean varieties were relatively unaffected by leafhopper damage during the wet season, while others suffered yield losses up to 40%. Screening for insect resistance is an important part of crop breeding programs.

"Organic" Controls

"Organic" control refers, in general, to non-chemical methods, including the application of homemade "natural" sprays made from garlic, pepper, onions, soap, salt, etc., and the use of materials like beer to kill slugs and wood ashes to deter cutworms and other insects. Some of these "alternative" insecticides are slightly to fairly effective on small areas like home gardens and where insect populations are relatively low. They are seldom feasible or effective on larger plots, especially under tropical conditions that favor insect buildup.

CHEMICAL CONTROL

Chemical control refers to the use of commerical insecticides in the form of sprays, dusts, granules, baits, fumigants, and seed treatments. While some of these insecticides like Bacillus thuringiensis, rotenone, and pyrethrin are naturally derived, most are synthetic organic compounds that have been developed through research.

Advantages of Insecticides

1. Rapid action.

2. They are the only practical means of control once an insect reaches the economic threshold of damage on a commercial size plot.
3. Insecticides are available in a wide range of properties, species effectiveness, and application methods.

4. They are relatively inexpensive, and their proper usage can often return $4-$5 for every $1 spent.

Disadvantages of Insecticides

1. Insect resistance to pesticides is a growing problem. In 1961, about 60-70 species had developed resistance to certain products, and the number had increased to around 200 by the mid-1970's.

2. Outbreaks of secondary pests: Few insecticides kill all types of insects, and some actually promote the increase of certain pests. For example, continual use of Sevin (carbaryl) in the same field may increase problems with some types of aphids which it doesn't control well.

3. Damage to non-target species such as beneficial predators, bees, and wildlife.

4. Residue hazards: Some chlorinated hydrocarbon compounds like DDT, Aldrin, Endrin, Dieldrin, and Heptachlor are highly persistent in the environment and may accumulate in the fatty tissues of wildlife, livestock, and humans. It's important to realize that many other insecticides are broken down into harmless compounds fairly rapidly.

5. Immediate toxicity: Some insecticides are extremely toxic in small amounts to humans and animals. Again, it's important to realize that insecticides vary greatly in their toxicity.

Current Status of Insecticide Use

At the present time and for the immediate future, insecticide usage will often be an essential part of any package of improved practices for the reference crops. For this reason, we urge all ag field workers to learn the basic principles of safe and effective insecticide application. Even though you may be personally opposed to these chemicals, you should realize that farmers throughout the LDC's are using them, often in an unsafe and indi-

criminate manner. Most of these countries have few, if any, pesticide regulations or restrictions on environmentally harmfully products like Aldrin or highly toxic ones like Parathion. By instructing farmers in safety precautions and in the appropriate choice and use of insecticides, the incidence of human poisoning and possible environmental damage can be greatly reduced.

INTEGRATED PEST CONTROL

The disadvantages of total reliance on insecticides have given rise to integrated pest control or pest management which involves the judicious use of these chemicals based on the following guidelines and principles:

1. The development and use of cultural and other non-chemical control methods to avoid or reduce insect problems.

2. (Economic Threshold) Determining crop tolerance to pest damage based on the principle that complete freedom from pests is seldom necessary for high yields. Nearly all plants can tolerate a surprising amount of leaf loss before yields are seriously affected.

3. The appropriate timing and frequency of treatments to replace routine, preventive spraying. Treatments are not initiated before the particular insect has reached the economic damage threshold which will vary considerably with the species. Insect scouting and population counts are an essential part of this system.

The advent of integrated pest control dates back to the early 1970's, and much of the effort has been directed at cotton where insecticides frequently account for up to 80% of total production costs. Some remarkable successes have been achieved with other other crops as well. In terms of the reference crops, integrated pest control is still in the very early stage, especially in the LDC's.

WEED CONTROL

I. HOW WEEDS LOWER CROP YIELDS

1. They compete with the crop for water, sunlight, and nutrients.

2. They harbor insects, and some weeds are hosts for crop diseases (especially viruses).

3. Heavy infestations can seriously interfere with machine harvesting.

4. A few weeds like Striga (witchweed) are parasitic and cause yellowing, wilting, and loss of crop vigor.

Extent of Yield Losses

Numerous trials in the U.S. have shown maize yield losses ranging from 41-86% when weeds weren't controlled. One trial in Kenya yielded only 370 kg/ha of maize with no weed control compared to 3000 kg/ha for clean weeded plots. A CIAT trial with beans in Colombia found a yield drop of 83% with no weeding.

Of course, all farmers weed their fields to some extent, but most of them could significantly increase their crop yields if they did a more thorough and timely job. A University of Illinois (U.S.) trial showed that just one pigweed every meter (40") along the row reduced maize yields by 440 kg/ha (390 lbs./acre). By the time weeds are only a few inches tall, they have already affected crop yields.

Relative competitive ability of the reference crops: Slow starters like peanuts, millet, and sorghum compete poorly with weeds during the first few weeks of growth. Low growing crops like peanuts, bush beans, and bush cowpeas are fairly effective at suppressing further weed growth once they are big enough to fully shade the inter-row spaces. However, tall growing weeds that were not adequately controlled earlier can easily overtake these "short" crops.

II. SOME IMPORTANT FACTS ON WEEDS

Broadleaf vs. Grassy Weeds

Broadleaf weeds have wide (broad or oval shaped) leaves with veins that form a feather-like pattern. Grassy weeds are true grasses and have long, narrow leaves with veins that run up and down in a parallel pattern. A few weeds like nutsedge (nutgrass) belong to neither category but are sedges, all of which have triangular stems. Some chemical herbicides are more effective on broadleaf weeds, while others give better control of grassy types.

How Weeds Reproduce and Spread: Annuals vs. Perennials

Annual weeds live only a year or so and reproduce by seed: they are the most common weeds in many fields. In the tropics, annuals may live more

than a year if rainfall is sufficient. Most annuals produce tremendous amounts of seed, some of which may not germinate for years. When you stir the soil with a hoe, harrow, or cultivator to kill weeds, you destroy one crop of them but encourage another by moving more weed seeds closer to the surface where they can sprout.

You can help lower a field's population of annual weeds by controlling them before they produce seed. Permanent eradication of annual weeds isn't possible because most fields contain millions of weed seeds waiting to germinate, and the supply is continually replenished by more seeds brought in by wind, water, animals, animal manure, and by contaminated crop seeds.

Perennial weeds live more than 2 years. Most produce seed but many also propagate means of creeping above-ground stems (stolons) and creeping underground stems (rhizomes). Johnsongrass, Bermudagrass, quackgrass, and nutsedge are some of the more aggressive perennial weeds. Hoeing or mechanical cultivation may actually aid in spreading them around the field. Most herbicides will kill only the top growth, and there is enough food in the underground parts to continue propagation.

Identifying Weeds

Where weeds are being controlled by hoeing or mechanical cultivation, their specific identification is usually not important. However, where chemical weed control is used, you and the farmer should have a good idea of which specific weeds are present, because most herbicides do not give broad-spectrum control. The following extension publication is an excellent identification guide and has pictures and descriptions of some 150 common weeds found throughout the tropics and sub-tropics:

"Weeds of the Southern United States, available from the Cooperative Extension Service of Clemson University, Clemson, South Carolina, U.S.A. 29631

III. A LOOK AT DIFFERENT WEED CONTROL METHODS

Let's look at the pros and cons of the following weed control methods:

1. Burning
2. Mulching
3. Shading (the row crop principle)
4. Hoe and machete cultivation
5. Animal and tractor-drawn cultivation
6. Herbicides

1. Burning

When land is cleared by burning, standing annual weeds are killed along with weed seeds very near the soil surface. However, burning will not kill weed seeds or reproductive underground parts of perennial weeds if they are deeper than 4-5 cm (2"). Furthermore, as the brush is often placed in windrows or piles before burning, much of the soil may not be affected by the fire. Some perennial tropical grasses such as Guinea (Panicum maximum) and

speargrass (Imperata cylindrica) are actually stimulated into dense regrowth by burning. On the other hand, weeds may be less of a problem under slash and burn farming, because the soil is usually not turned by plowing or cultivation to bring up more weed seeds.

2. Mulching

Mulching the soil surface with a 10-15 cm (4-6") layer of crop residues, dead weeds, or grass can give very effective weed control and provide a number of other benefits:

a. Erosion is greatly reduced on sloping soils.

b. Soil water loss by evaporation and runoff is greatly reduced.

c. In very hot areas, soil temperatures are reduced to a more beneficial level for crop growth.

d. Organic matter is eventually added to the soil.

In trials conducted by IITA in Nigeria, mulching increased maize yields by 23-45% and greatly reduced the heavy labor requirement for hand weeding which accounts for 50-70% of the hours needed to grow maize in that area.

3. The Row Crop Principle

Arranging crops in rows facilitates hand weeding but also makes possible mechanical cultivation (weeding) with tractor or animal-drawn equipment. The rows also permit the crop to exert better shade competition against the weeds.

4. Hoe and Machete Cultivation

Weeding with hand tools is an effective method if sufficient labor is available. However, small farmers who rely on this method commonly fall behind in weeding, and crop yields often suffer.

5. Animal and Tractor-drawn Cultivation

Disk harrows, field cultivators, and spike tooth harrows can provide excellent pre-planting weed control. The spike tooth harrow can also be used to control emerging weeds up until the crop is about 7.5-10 cm (3-4") tall without serious damage.

Animal and tractor-drawn row cultivators can be used from the time the crop is a few inches tall; they do a much more rapid job than hand weeding. A one-row animal drawn model can easily cover 3-4 hectares/day (7.5-10 acres) unless the rows are very narrow. They can be adjusted to throw soil into the row itself to kill small weeds by burying them. If operated too deeply or too close to the row, serious root pruning may result.

6. Herbicides

Herbicides can greatly reduce labor requirements and permit a farmer to grow a larger acreage; they can also avoid root pruning damage, soil compaction, and stand reduction which are caused by hand tools or mechanical equipment. In a number of cases, herbicides like Gesaprim (atrazine, see herbicide section) and 2,4-D have proven competitive with hand labor in maize production in the LDC's. IITA is working on improved methods for small farmer application of herbicides such as granular forms and ultra low volume sprayers.

Herbicides do have some very definite disadvantages that must be considered.

1. They are less reliable than hand tool or mechanical weeding most require careful and accurate application. This can be achieved by using backpack sprayers, but it requires some training.

2. Weed control is seldom complete; most herbicides are not broad-spectrum. It's important to analyze the type of local weed species present before choosing a product.

3. Most soil applied herbicides require a certain amount of rain within a week after application in order to move the chemical into the zone of weed seed germination. Others need immediate incorporation into the soil with a disk harrow or rototiller.

4. Improper application may damage the crop.

5. Nearly all herbicides are unsuited for use in intercropping involving cereals and legumes due to crop injury; these products are crop-specific as well as weed-specific.

USING CHEMICAL INSECTICIDES

I. SOME IMPORTANT FACTS ON INSECTICIDES

Pesticide Terminology

Pesticide: A general term referring to chemicals that control crop insects, weeds, diseases, and nematodes.

Miticide (acaricide): A pesticide that kills mites; mites are more related to spiders than insects and not all insecticides will kill them. Some pesticides like dicofol (Kelthane) control only mites, while others like Diazinon (Basudin) and Malathion kill mites and other insects. Sevin (carbaryl) won't control mites.

Nematocide: A pesticide that kills nematodes, A few insecticides like Furadan and Mocap will also control nematodes, but most will not. Some nematocides like Nemagon control only nematodes, while others like VAPAM, Basamid, and methyl bromide are general soil sterilants that kill insects, weeds, fungus, and bacteria as well.

How Insecticides Kill Insects

Nearly all modern insecticides are contact poisons that kill insects by being absorbed through their bodies. Contact poisons act as stomach poisons if eaten by insects.

Systemic vs. Non-Systemic Insecticides

Most insecticides are non-systemic and are not absorbed into the plant. Systemic insecticides are absorbed into the plant sap, and most are translocated (transported) throughout the plant. Most systemic insecticides like Metasystox, Dimethoate (Rogor, Perfekthion), and Lannate are sprayed on plant foliage. Others like Furadan, Thimet, and Di-syston are applied to the soil in a band along the crop row where they are absorbed by the plant roots and then translocated to the stems and leaves. Some of these soil applied systemics will also control certain soil insects.

When choosing between a systemic and non-systemic insecticide, you should consider the following:

1. Systemic insecticides are especially effective against sucking insects like aphids, leafhoppers, stinkbugs, and thrips since these feed on the plant sap. However, many non-systemic contact insecticides will also control sucking insects adequately.

2. Most systemics are less effective against caterpillars and beetles but may give good control of some stem borers.

3. Foliar applied systemics may remain in the plant for up to 3 weeks. Soil applied systemics may provide control for up to 6 weeks. However, this also means that they must not be applied close enough to harvest time to cause residue problems.

4. Most systemics will not harm beneficial insects.

5. Foliar applied systemics are not broken down by sunlight or washed off the leaves by rainfall as with non-systemics.

6. Since they are translocated, systemics don't require uniform spray coverage when they are applied to the leaves. New growth occurring after application is also protected.

7. Some systemics like Thimet, Di-syston, and Systox are highly toxic both orally and dermally. However, the same is also true with some non-systemics like Parathion and Endrin.

A GUIDE TO TROUBLE-SHOOTING COMMON CROP PROBLEMS

It takes a lot of practice and detective work to accurately trouble-shoot crop problems. Some abnormalities like wilting or leaf yellowing can have numerous causes.

How to Troubleshoot: First, learn to distinguish normal from abnormal growth when you walk through a farmer's field. Keep a close watch for tell-tale trouble signs such as abnormal color, stunting, wilting, leafspots, and signs of insect feeding. Make a thorough examination of affected plants, including the root system and the inside of the stem, unless the problem is obvious. Obtain detailed information from the farmer concerning all management practices that might have a bearing on the problem (i.e., fertilizer and pesticide applications, name of crop variety, etc.). Note whether the problem occurs uniformly over the field or in patches; this can provide valuable clues; since some problems like nematodes and poor drainage seldom affect the entire field.

Troubleshooting tools, etc.

1. A pocketknife for digging up seeds or slicing plant stems to check for root and stem rots or insect borers.

2. A shovel or trowel for examining plant roots or checking for soil insects or adequate moisture.

3. A pocket magnifying glass to facilitate identification of insects and diseases.

4. A reliable soil pH test kit for checking both topsoil and subsoil pH; especially useful in areas of high soil acidity. Beware of cheap kits, especially those using litmus paper. The Hellige Truog kit is one of the best and costs about $15 (U.S.).

5. Disease, insect, and hunger signs guides: Refer to the Bibliography an the end of the Crops Guidelines.

TROUBLESHOOTING GUIDE

CROP APPEARANCE	PROBABLE CAUSES
POOR SEEDLING EMERGENCE (Carefully dig up a section of row and look for the seeds)	Low germination seed Planting too deep or too shallow Soil crusting or overly cloddy soil Lack of moisture Clogged planter Seeds washed out by heavy rain Fertilizer "burn" Pre-emergence damping off disease Birds, rodents Seed eating insects (wireworms, seed corn maggots, seed corn beetle)
WILTING (Pull up a few plants carefully using a shovel or trowel and examine the root; check stem for borers or rotted or discolored tissue.)	Actual lack of moisture due to drought or poor irrigation management (watering too lightly or too infrequently) Diseases (bacterial or fungal wilts; certain types of root and stem rots) Very high temperatures, especially if combined with dry, windy conditions. Root feeding insects Stem borers Weed competition Root pruning by hoe or cultivator Nematodes (especially if confined to patches and when plants wilt despite having sufficient water) Stem breakage or kinking
LEAF ROLLING OR CURLING	Lack of moisture (maize, sorghum, millet) Virus Sucking insects feeding on stem or leaves Boron, calcium deficiency (beans only) Verticillium wilt (peanuts)
LEAF CRINKLING, PUCKERING	Aphids, leafhoppers feeding on leaves or stems Virus
LEAF "BURNING" OR BROWNING	Drought Excessive heat Fertilizer burn Insecticide burn Dipterex, Azodrin (Nuvacron), or methyl parathion injury on sorghum Herbicide damage Nutrient deficiency Aluminum, iron, or manganese toxicity

CROP APPEARANCE	PROBABLE CAUSES
	due to excessive acidity (below pH 5.5). Salinity or sodium problems (confined largely to low rainfall areas, especially if irrigated) Boron toxicity from irrigation water (low rainfall areas) or improper placement of fertilizer boron
LEGGY, SPINDLY PLANTS	Lack of sunlight caused by overcrowding or long periods of heavy cloudiness
HOLES IN LEAVES	Caterpillars Beetles Earwigs Crickets Snails, slugs, especially on beans (check for slime trails) Breakdown of dead tissue due to fungal or bacterial leafspots
SPOTS ON LEAVES	Fungal or bacterial leafspots Virus Sucking insects Spilling of fertilizer on leaves Herbicide spray drift, especially paraquat (Gramoxone) Sunscald (beans)
LEAF MALFORMATION WITH STEM CURVING & TWISTING (Broadleaf plants only)	2, 4-D type herbicide damage due to spray drift or a contaminated sprayer (broadleaf crops only).
LEAF MOTTLING, LEAF MALFORMATION, PLANT MALFORMATION	Virus
LEAF STRIPING	Nutrient deficiency Virus Genetic

Troubleshooting Guide (cont'd)

CROP APPEARANCE	PROBABLE CAUSES
YELLOWING, STUNTING	Nutrient deficiency Poor drainage Nematodes Low pH (excessive acidity) Root rot, stem rot, miscellaneous diseases
OVERNIGHT DEFOLIATION OF PLANTS	Leaf cutter ants, grazing animals
PLANTS CUT OFF AT OR NEAR GROUND LEVEL	Cutworms Mole crickets
TWISTING TUNNELS IN LEAVES	Leaf miners
YOUNG SEEDLINGS COLLAPSE NEAR GROUND LEVEL AND DIE	Fungal seeding blights, damping off, heat girdling of stem (beans)
POOR GROWTH, LACK OF VIGOR	Too dry or too wet Too hot or too cold Insects, diseases Weeds Unadapted variety Low pH Salinity-alkalinity problems Overcrowding Shallow soil Soil compaction, hardpan Poor drainage Nutrient deficiency Faulty fertilizer practices Nematodes Excessive cloudiness Herbicide carryover Overall poor management Damaged seed (beans)
LODGING OR STALK BREAKAGE (Maize, Sorghum, Millet)	Overcrowding Stalk rots Rootworms High wind Potassium deficiency

Troubleshooting Guide (cont'd)

CROP APPEARANCE	PROBABLE CAUSES
POOR NODULATION ON PEANUTS, COWPEAS, SOYBEANS, OTHER LEGUMES THAT ARE EFFICIENT FIXERS (Carefully dig up the root system and check for nodulation; clusters of fleshy nodules, especially on the taproot, and with reddish interiors are signs of good nodulation. Don't confuse nodules with nematode galls!)	Soil lacks the correct type of Rhizobia; seed innoculation is needed. Improper innoculation: wrong strain, innoculant too old or improperly stored. Exposure of innoculated seed to excessive sunlight or contact with fertilizer or certain seed treatment fungicides. Excessive acidity (soybeans are especially susceptible to Molybdenum deficiency). Plants are too young (it takes 2-4 weeks after plant emergence for the nodules to become visible).

WHEN TO HARVEST VEGETABLES

BEANS, green: Harvest bush beans while the pods will still "snap" and before they become lumpy. Bush bean varieties have a harvest period of about 2-3 weeks; pole (vine) varieties have a 6-8 week harvest period, and the pods are picked when large and thick.

BEETS: Ready to harvest as soon as they're 1-1/4 to 2" in diameter (about golf ball size). Sugar content increases with age but so does toughness.

BROCCOLI: Harvest just after the individual flower buds become distinguishable but before the clusters begin to open and turn yellow. Center head is usually 3-6" across; side shoots continue developing after center head is cut and will reach 1-3" in diameter. Making a slanting cut may help prevent stem rot.

CABBAGE: Can be harvested as soon as the head has formed since flavor doesn't change much with maturity--you'll sacrifice yield though. Use a sharp knife and cut close to the head. Heads will sometimes split during hot weather when large. Twist the plant about 1/4-1/2 turn til you hear some of the roots snap--it'll slow growth and reduce splitting (do it near maturity). If bacterial soft rot is a problem, dip knife and stem of cabbage in a 1% solution of household bleach in water (10 cc bleach per liter).

CARROT: Harvest can start when the roots are about 1" in diameter at the crown; don't let 'em get more than 1-1/2".

CANTALOUPE (Muskmelon): A common guide is the ease of melon removal from the vine; fully ripe ones (called "full slips") separate easily and leave a clean stem cavity; full slips have poor storage life except under refrigeration. Half slips are less mature and take more pressure to detach (about half of stem next to the melon remains attached) and store longer. Both full and half slip melons are fully netted and the color has changed from cucumber green to mottled green and light yellow.

CAULIFLOWER: Timely harvest is important to prevent ricey or fuzzy curds. If weather is warm, heads can mature within 3-5 days after blanching (see below) starts but can take up to 2 weeks in cooler weather. Mature heads are fully developed, compact, and clear white; about 6" is the best size for harvest. Use a large knife to cut the heads from the plants and leave one or more sets of leaves attached to protect the curds; avoid overmature, open heads.

Blanching: Curd becomes discolored and sometimes off-flavored if exposed to sunlight; when small, they're protected by the inner leaves; as curds enlarge, in most varieties they force the inner leaves apart, so blanching is needed. Gather longest leaves together over the curd and tie with soft twine; since the plants

mature at different rates; you'll need to go through the field every 2-3 days to do blanching: using different color twine each day will aid in maturity detection. Some self-blanching varieties are available.

CHARD, Swiss: Harvest outer leaves first as they reach tender maturity (blade will be about 6-10" long); new ones will continue developing.

CHINESE CABBAGE: There are 2 ways to harvest Chinese Cabbage:

1. Harvest when heads are solid and 6-8" across. Cut with a knife at the base of the head and remove any dead, yellowed or dirty leaves around the outside. It doesn't store or ship as well as regular cabbage; the heads can be packed loose in boxes or first rolled in newspaper. Letting the heads wilt before boxing them helps prevent breakage--buyers can recrisp them by soaking them for a few minutes.

2. Harvest the outer leaves as they reach about 6-8" in length; new ones will continue developing for many weeks. They'll also be much higher in vitamin A than the paler leaves inside a head due to better sun exposure.

CHAYOTE (Guisquil, Vegetable Pear): 25-30 days after fruit set.

COLLARDS: Two ways to do it:

1. Harvest outer leaves when full size but still tender.

2. Harvest the entire plant at once before leaf stems become tough and fibrous.

CUCUMBER: Fresh market (slicing) cukes can be picked at any size, but a medium size, dark green cuke is best. Don't let them reach the full yellow ripe stage since it'll reduce total yield. Picking should be done every 2-3 days; hold the vine and twist off the fruit (pulling may damage vines).

EGGPLANT: Higher total yields are attained if the fruits are picked before reaching full size; they're ready any time after the fruit is 1/3 size with skin showing a slick luster; skin should be firm to the touch. If the seeds are brown or the skin remains indented after being pressed with the thumb, it's overripe. Cut off the fruit, don't pull, leave the calyx (cap) attached to the fruit. Handle carefully to avoid bruising.

GARLIC: Ready to harvest after the tops have died; in rich soil, tops may need to be broken over to prevent too much top growth. Plants are pulled and placed in windows with tops covering bulbs to prevent sunscald. Curing takes several days and can be done indoors if rainy.

LETTUCE: Leaf lettuce is ready as soon as the leaves are big enough; the entire plant can be harvested or you can prolong the harvest (up to 2 months or more) by picking the outer leaves as they develop.

MUSTARD: Pick outer leaves when 4-6" long; plant will continue producing new leaves.

NEW ZEALAND SPINACH: Pinch off about 3" of branch tips with leaves; more side shoots will keep appearing.

OKRA: Pods are usually picked 3-5 days after flowering when 2-3" long; pick pods daily to keep plant producing and to avoid overmaturity. Okra deteriorates rapidly after harvest.

ONIONS: Can be harvested either as green bunch or mature bulbs; suitable for green bunch harvest from the time they're pencil size. As mature bulb stage nears, some of the tops will fall over at the neck. Break over all tops at this time to assure uniform maturity. In the dry season, they can be cured in the field—shade the bulbs with the tops to minimize sunscald. One half to one inch of top is usually left on the bulb to prevent disease entrance.

Once way to speed up maturation and get larger bulbs is to break over the tops when the outer leaves turn yellow; 2 weeks later, loosen the bulbs by pushing a spading fork beneath them and lifting slightly; in another 2 weeks, lift them out after they're dried; spread out in a warm, airy place for a few days to cure, then braid 'em together and hang 'em up.

PEPPER: Bell peppers are usually picked while still green (before they turn yellow or red); they can be harvested for home use when quite young, but the fruit will wilt quickly. Cut, don't tear the fruit from the plant and leave a portion of the stem on the fruit.

POTATO: Can be harvested at any size but usually best to let them grow to full size (until the vines die off), barring market considerations. The vines should be dead before harvest for 2 reasons: (1) So the skins will "set" (harden); (2) To prevent transfer of late blight spores from the vines to the tubers which can cause them to rot; vines can be killed by topping or with Gramoxone or Reglone. Handle carefully to avoid bruising.

RADISH: Harvest can start as soon as they reach small acorn size. Once much bigger than 1", they begin to split and get hot and pithy. Normal harvest is 3-4 weeks after planting. Use the tops as greens (much higher in vitamins, minerals).

SQUASH: Summer varieties like Zucchini and Yellow Crookneck are ready when the thumb makes an imprint on the skin; winter types are ready when the skin resists thumb pressure; cut off the fruits, don't twist or pull (avoids vine damage).

SWEET POTATOES: Best way is to dig up a few and see if they're the size you want; small fruits have more flavor and are easier to bake; large tubers mean larger yields. Yellowing of the lower leaves is usually a sign of approaching maturity.

TOMATO: For canning and pasta, harvest fully ripe; for local markets, pick at the hard ripe to pink stage. For distant shipping, at the mature green stage. The longer they can be left on the vine, the higher the quality. Mature greens ripen in 6-20 days at 70°F and don't color faster at higher temperatures; keep out of sun; ripen best in dark.

Mature green test: Cut cross-wise with a sharp knife; if the seeds give way without being cut, it's mature; fruit also has a brownish ring at the stem scar after the calyx (cap) is removed, and the light green color at the blossom end has turned yellow green.

Hard ripe stage: nearly all red or pink but flesh is firm.

Over-ripe: Fully colored but soft.

Leaving fruits on the vine won't reduce yields.

TURNIPS: When roots reach 2 to 2-1/2" in diameter; use the tops as greens; they're much higher in vitamins and minerals.

WATERMELON: Don't harvest immature or won't have good flavor or color; here are several tests:

1. "Thump" test: Green ones have a metallic ring; mature ones, a muffled sound.

2. Watch the tendrils (pigtails) on the stem near the fruit; the first tendril going to the fruit will die (wither) first, but don't pick yet; wait til the tendrils on either side of the one attached to the fruit die.

3. Watch bottom of melon where it rests on the ground; when it changes from white to light yellow with little or no green, it's ready.

4. The melon will lose its shine and have a slight cast to it.

Leave about 2" of stem attached to the fruit when picking.

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